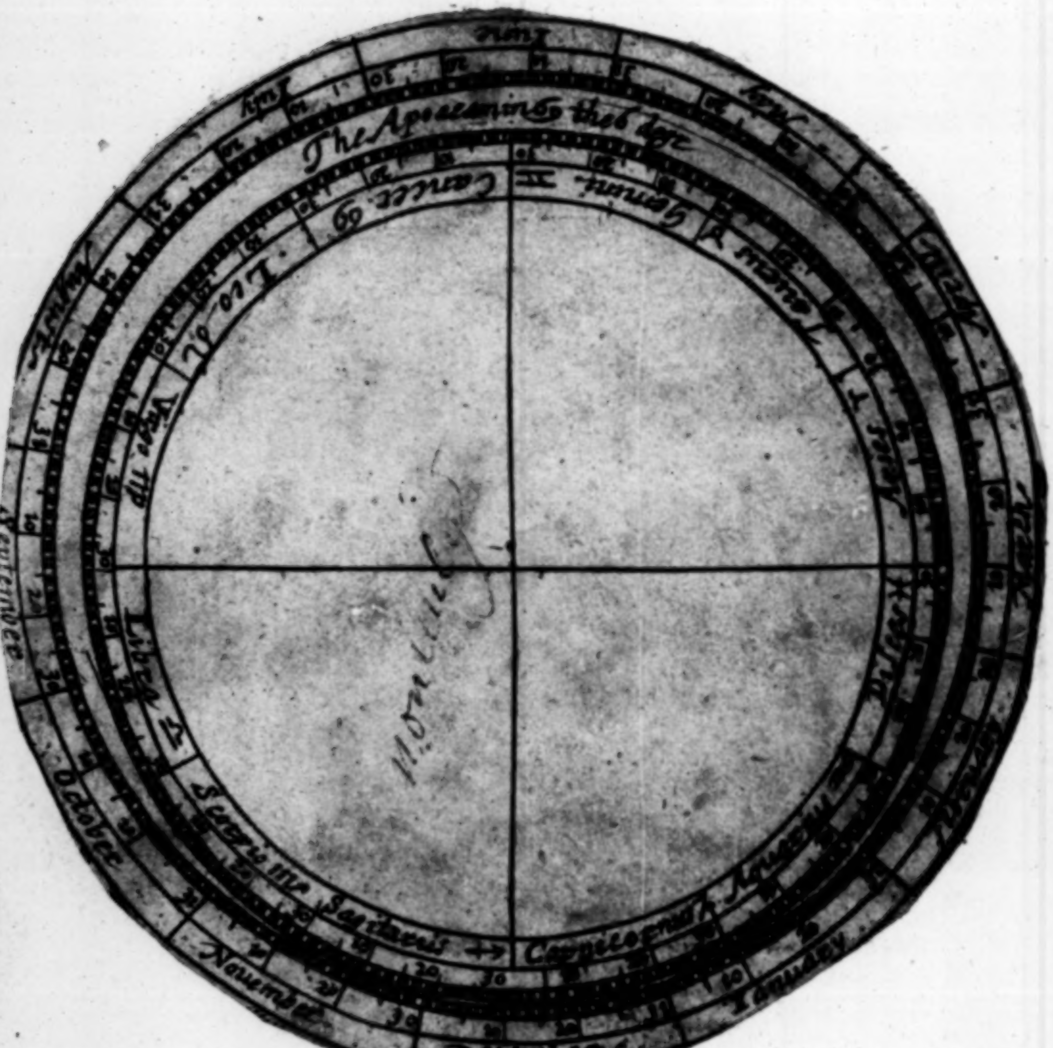
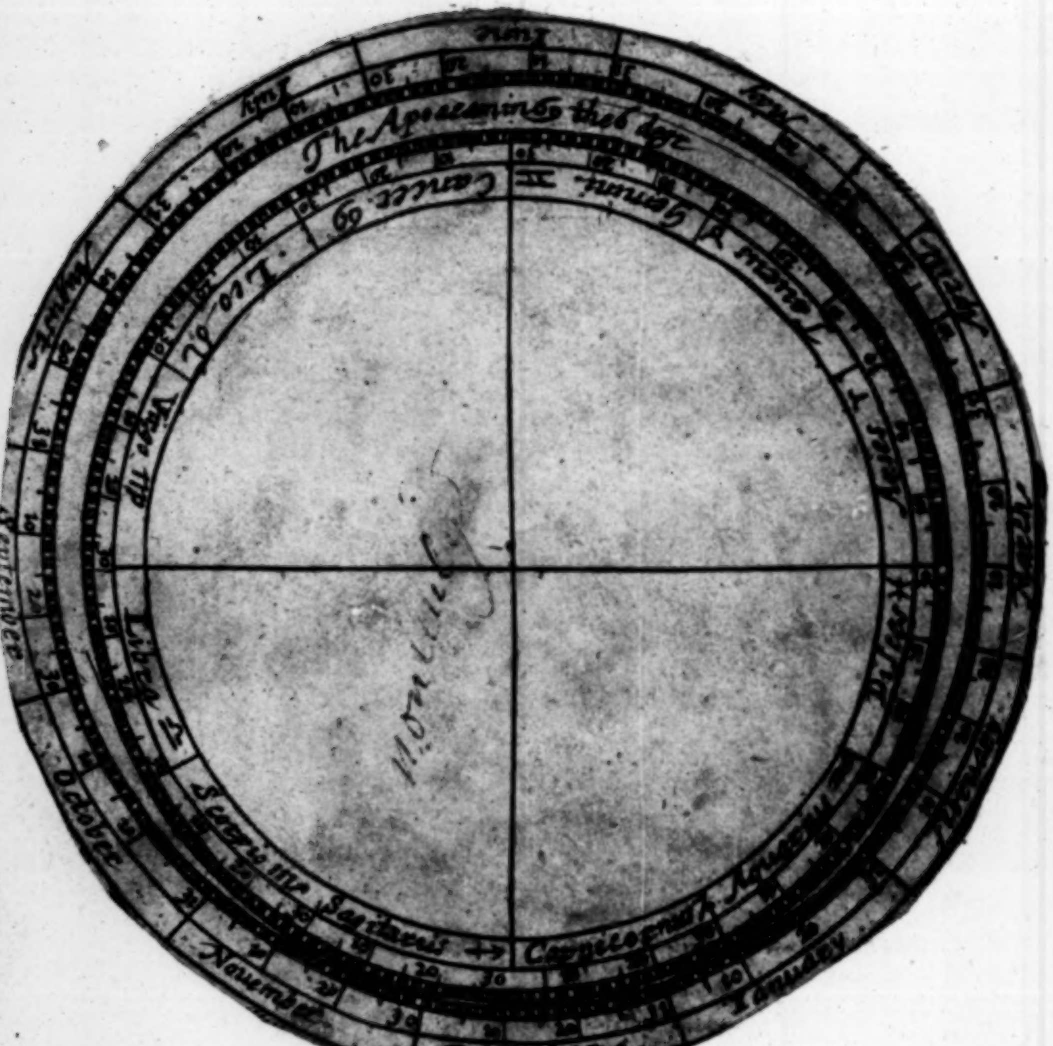
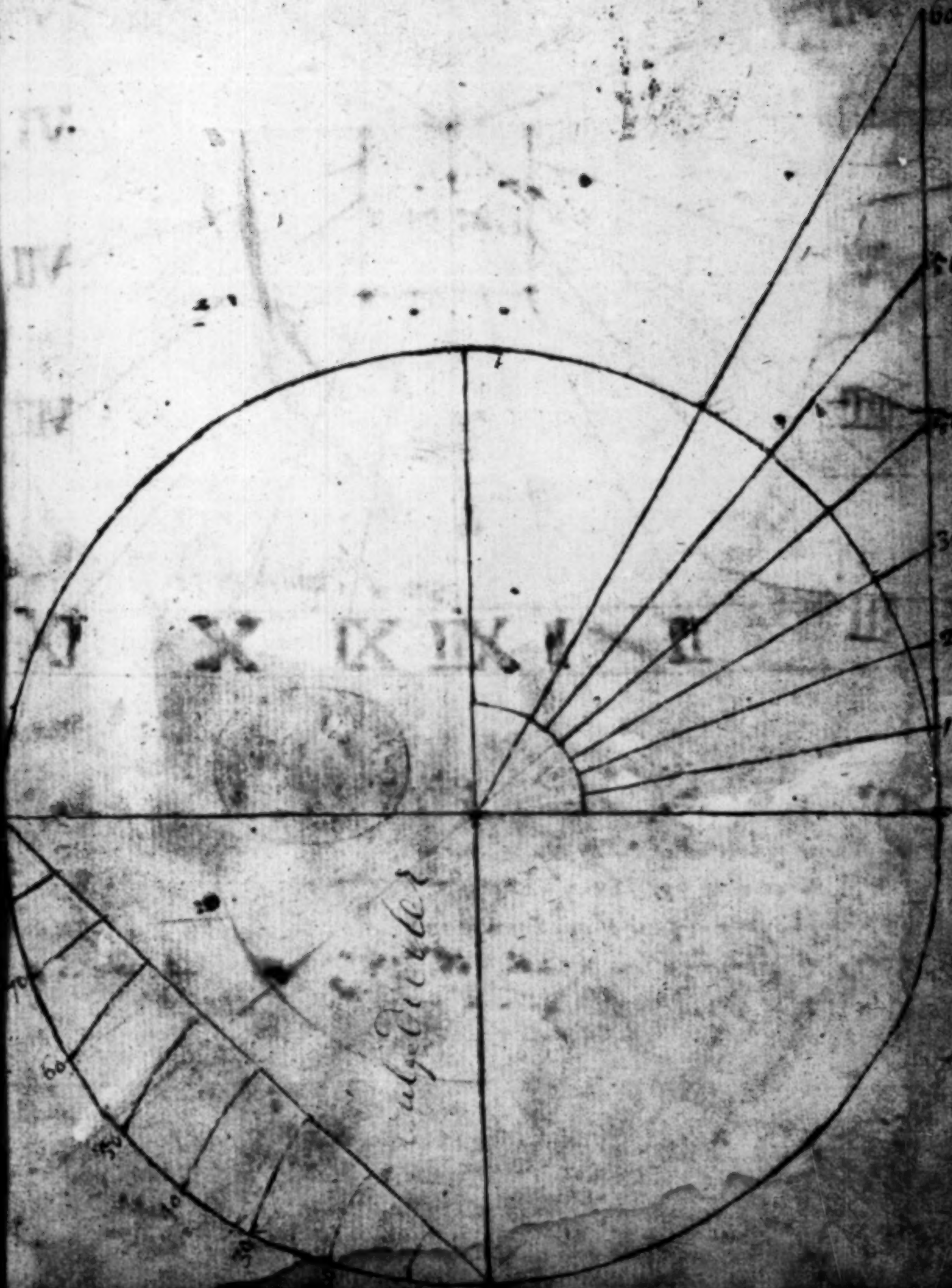
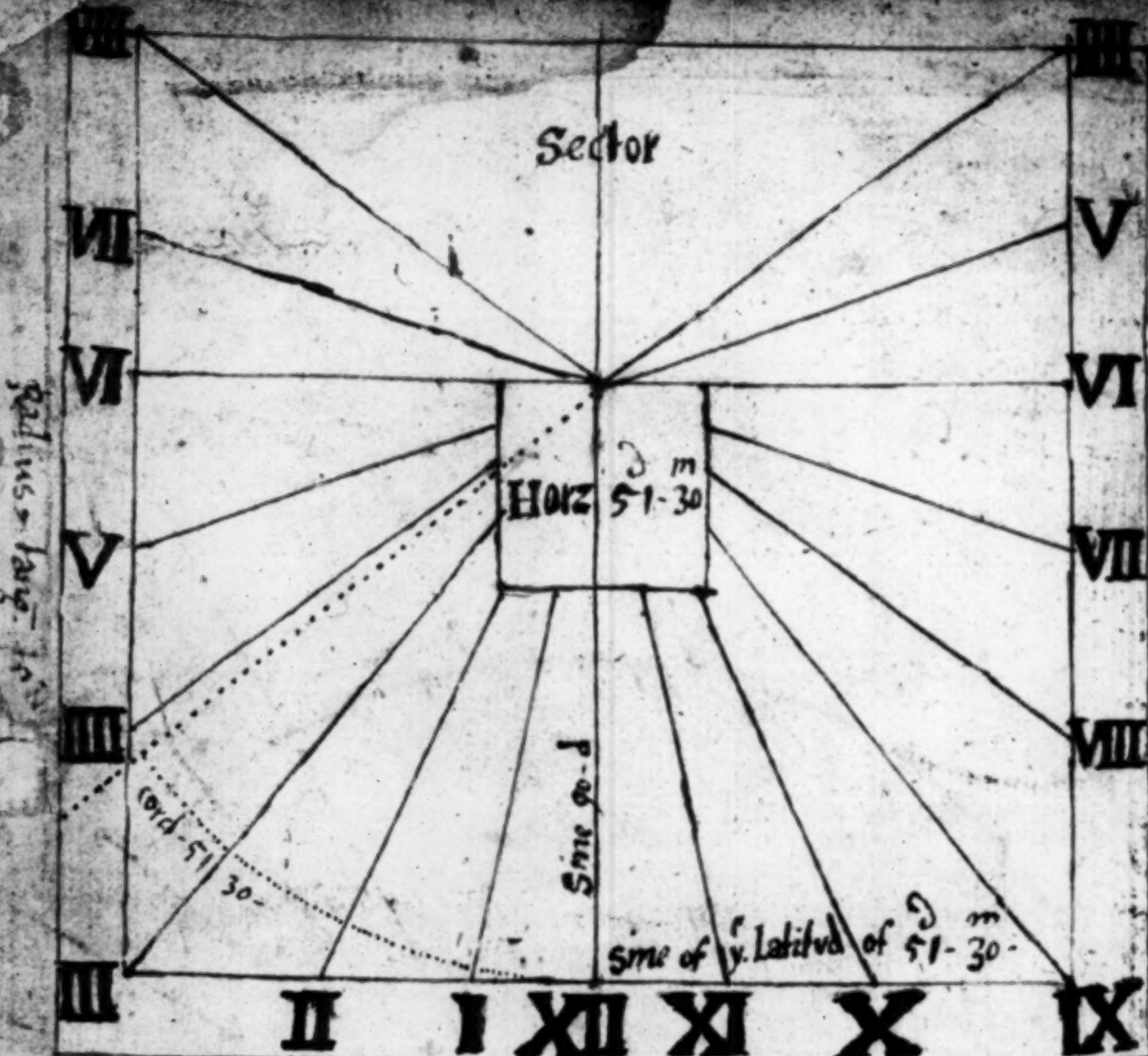

September
October
December
January
Libra
Sagitarius
Capricornus



Sagittarius
Capricornus
Aquarius
Libra
Virgo
Leo
Cancer
October
November
December


60
50
40
30
20
10
70
60
50
40
30



Radius - sine of 90d: or a tanget of 45:
yn a sine of Latitud of 51. d & 30 m - wch turne
into A tangent of 45. - for ye hours -
stiles height - ye Ra - sine of 90d turn it into
a tang. of 30d - yn a sine of 25 d & $\frac{3}{4}$ for
ye stile - to be prickt in ye Ark - - -

Inscription about ye monument on fishstreet hill

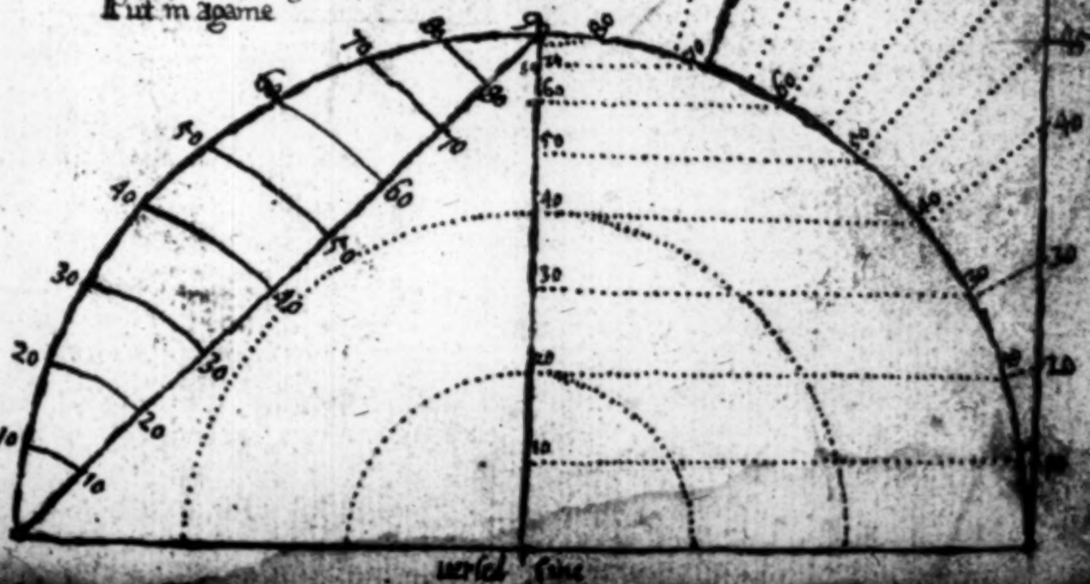
This pillar was set vp ~~in~~ perpetuall Remembrance
of the most dreadfull burning of this
protestant city begun & caried on
by the treachery & malice of the
papists in the Beginning of
Sept: in the year of ~~the~~ our
Lord 1666 in order to the
carrying on their horid
plot for extarpating the
protestant Religion
the old english
liberty and
Introduceing
popery &
slavery
3 Aug
1681

This pillar is of ye Dorick order 175 foot high from ye surface of ye ground & 15 foot diameter all of solid portland stone wth a stairs on ye middle of black marble wth an Iron belcony on ye top ye pedestall of this pillar is 21 foot square & 40 foot high not unlike those ancient white marble pillars at Rome erected in honor of ye emperors trajan & Antoninus those 2 excellent princes above 1500 year agoe & are still standing entire

Sir patience ward Lord mayor

taken out 20 June 1685

Put in againe



PANORGANON:

Lawrence OR, A Faierclough

Universal Instrument,

PERFORMING

All such Conclusions *Geometrical* and *Astronomical* as are usually wrought by the *Globes*, *Spheres*, *Sectors*, *Quadrants*, *Planispheres*, or other the like *Instruments*, yet in being; with Ease and Exactness.

[...]e Uses whereof are exemplified in the solution of such [...]roblems as are of frequent use in the practise of

Geometry	&	*Geography*
Astronomy	&	*Trigonometry*
Dialling	&	*Projection*, &c.

Geometry
Geography
Astronomy
Trigonometry
Dialling
Projecting

By *William Leybourn*, Philom.

+ a lover of learning

LONDON,

Printed for *William Birch*, at the Sign of the Bible at the corner of the *Poultry* and *Bucklersbury* at the lower end of *Cheapside*, 1672.

PANORGANON:

Lawrence OR, A Faierclough

Univerſal Inſtrument,

PERFORMING

All ſuch Concluſions *Geometrical* and *Aſtronomical* as are uſually wrought by the *Globes*, *Spheres*, *Sectors*, *Quadrants*, *Planiſpheres*, or other the like *Inſtruments*, yet in being; with Eaſe and Exactneſs.

Some Uſes whereof are exemplified in the ſolution of ſuch Problems as are of frequent uſe in the practiſe of

Geometry	*Geography*	Geometry Geography
Aſtronomy	*Trigonometry*	Astronomy Trigonometry
Dialling	*Projection*, &c.	Dialling Projecting

k By *William Leybourn*, Philom.

+ a lover of learning

LONDON,

Printed for *William Birch*, at the Sign of the Bible at the corner of the *Poultry* and *Bucklersbury* at the lower end of *Cheapſide*, 1672.

PANORGANON:

OR A

Universal Instrument

PERFORMING

All such Conclusions Geometrical and Astronomical as are usually wrought by the Globes, Spheres, Sectors, Quadrants, Planispheres, or other the like Instruments, yet in being, with Ease and Exactness.

Some Uses whereof are exemplified in the solution of such Problems as are of frequent use in the practice of

Geometry, Geography,
Astronomy, Trigonometry,
Dialling, Navigation &c.

By William Leybourn, Philom.

LONDON,

Printed for William Birch, at the Sign of the Bible at the corner of the Poultry and Cheapside, or at the lower end of Cheapside, 1672.

HONORATISSIMO D^no

D^no HENRICO, Marchioni

DORCHESTRIENSI:

COMITI de *KINGSTON*, VICE-COMITI

de NEWARK, & BARONI

PEIRPONT, & MAUNVERS,

MATHEMATICARUM ARTIUM

PATRONO atq; FAUTORI SUMMO;

Gulielmus Leybourn

LUCUBRATIONES

SUAS

PRACTICO-MATHEMATICAS,

Hocq;

PANORGANON

NOVAM

DEBILA CUM HUMILITATIS.

D. D.D.

TO THE

READER

IF *I should here make mention of the several* Instruments *that have, from time to time, by several learned and ingenious men, been invented for the finding of the* Hour, Azimuth, *and other usual and necessary* Astronomical *and* Geometrical *Problems, I should exceed the bounds of a* Preface. *Wherefore (omitting to say any thing of those invented and published by* Orontius, Stoflerus, Clarius, *&c.) I shall only say somthing of that which hath hitherto received best acceptance, namely, that of Mr* Gunter, *which (though it be not an exact Projection of the Sphere) exceedeth any of the forementioned, yet that also is deficient, in respect it is particular for some one Latitude, and the* Hour *and* Azimuth *Lines (in all Latitudes) do occupie the most part of the whole surface of the Quadrant, and (in some Latitudes) they cannot both be inscribed (without confusion) upon the same side of the Instrument.*

The Quadrantal part of the Instrument here offered to thee, is quitted of both the forementioned incumberances, and hath many other conveniencies: For

(1.) *It is a perfect* Projection *of the* Sphere, *it being a part of the* ANALEMA.

(2.

[illegible] Line in each Latitude, serving to find both the Hour and Azimuth; and some other Problems besides (of good use) may be resolved by the same Line also: As by what is thereby performed in the Second Part of this Treatise may appear: For all the most usual Problems of the Sphere; the Requisites belonging to all the most usual sorts of Sun-Dials: And the Hour, Azimuth, Amplitude, &c: (not only of the Sun, but of the Stars also) may be found with facility and exactness: and if the Instrument be made but of 8 or 9 inches Radius, it shall give the Hour to a minute, and the Azimuth to less than half a degree, and that without the help of a Bead upon the String thereof, which upon the least stretching or shrinking of the Thred, altereth the Position thereof, and rendreth the work performed thereby imperfect.

Now for the manner of working the several Problems upon the Instrument, the lines thereof being thus disposed, within the confines of a Quadrant, I do confess I gained by being possessed of some few Precepts written by Mr. Samuel Foster, sometime Astronomical Professor in Gresham Colledge, for the use of a Quadrant for himself made in Anno 1644. which Quadrant, and the Precepts concerning the uses thereof, have been hitherto most earnestly desired and enquired after. And thus setting aside, (or acumulating to my self) any thing that may be termed Plagiarie, I do declare against; and thus much Reader I can freely say concerning the Quadrantal part of the Instrument, although I have added several Lines of my own thereunto.

Now

Now for the Wings *of the* Instrument, *they may be adorned* (Reader) *with what* Feathers *you please*; *I have made choise of such as you see in the* Scheme *of the* Instrument *before the Book annexed, as being the most useful and necessary, and as well disposed, as any I have yet seen: And if the two Rules delivered in the Section of the First Part of this* Treatise *be rightly understood, any* Canons, proportions, *or* Analogies, *in* Equal Parts, Sines, Tangents, *or* Secants *single or mixed, which you find in the Works of* Mr. Gunter, Mr. Oughtred, Mr. Foster, Mr. Wingate, Mr. Collins, *or other of my own Works, or of any other Author, you may easily (by observing the two* Rules *delivered in the forementioned* Section) *apply to, and perform by this Instrument. And for the manner of* working *upon* proportionable Lines, *by one* Line, *of a kind, the beforementioned* Mr. Foster *was the first that in the* English Tongue *ever published any thing concerning it, as in his alteration of the* Sector, *now printed with* Mr. Gunters *Works, doth appear. And the Instrument thus fitted I commend to thee, wishing thee much profit and pleasure in the use of it.*

Vale.

Advertiſement.

THis Inſtrument, or any other Mathematical Inſtrument, is exactly made either in Silver, Braſs, or Wood, by Mr. *Walter Hayes*, at the *Croſs-Daggers* in *Moore-Fields*, next Door to the *Popes Head* Tavern ; where they may have all ſorts of Maps, Globes, Sea-*P*lats, Carpenters Rules, Poſt and Pocket-Dials for any Latitude, Steel Letters, Figures, Sines, Planets, or Aſpects, at reaſonable Rates.

A Table of the Suns Place and Declination.

Days.	January. S. Place. d.	m.	S. Dec. d.	m.	Days.	February. S. Place. d.	m.	S. Dec. d.	m.	Days.	March. S. Place. d.	m.	S. Dec. d.	m.
01	21 ♑	45	21	46	01	23 ♒	15	13	49	01	21 ♓	21	03	27
02	22	46	21	36	02	24	16	13	29	02	22	20	03	03
03	23	47	21	26	03	25	17	13	09	03	23	20	02	40
04	24	48	21	15	04	26	17	12	48	04	24	19	02	16
05	25	50	21	04	05	27	18	12	27	05	25	19	01	52
06	26	51	20	52	06	28	18	12	06	06	26	18	01	29
07	27	52	20	40	07	29	19	11	45	07	27	18	01	05
08	28	53	20	27	08	00 ♓	19	11	24	08	28	18	00	41
09	29	54	20	14	09	01	19	11	02	09	29	17	00	18
10	00 ♒	55	20	01	10	02	20	10	41	10	00 ♈	16	00	06
11	01	57	19	48	11	03	20	10	19	11	01	16	00	30
12	02	58	19	34	12	04	20	09	57	12	02	15	00	54
13	03	59	19	19	13	05	21	09	35	13	03	14	01	18
14	05	00	19	05	14	06	21	09	13	14	04	14	01	41
15	06	01	18	50	15	07	21	08	51	15	05	13	02	25
16	07	02	18	35	16	08	21	08	28	16	06	12	02	59
17	08	03	18	19	17	09	21	08	06	17	07	11	03	02
18	09	04	18	03	18	10	22	07	43	18	08	10	03	16
19	10	05	17	47	19	11	22	07	20	19	09	09	03	39
20	11	06	17	30	20	12	22	06	57	20	10	08	04	02
21	12	07	17	14	21	13	22	06	34	21	11	07	04	25
22	13	08	16	56	22	14	22	06	11	22	12	06	04	48
23	14	09	16	39	23	15	22	05	48	23	13	05	05	11
24	15	09	16	21	24	16	22	05	24	24	14	04	05	34
25	16	10	16	03	25	17	21	05	01	25	15	03	05	57
26	17	11	15	44	26	18	21	04	38	26	16	02	06	19
27	18	12	15	26	27	19	21	04	14	27	17	01	06	42
28	19	13	15	07	28	20	21	03	51	28	18	00	07	05
29	20	13	14	48						29	18	58	07	27
30	21	14	14	28						30	19	57	07	49
31	22	15	14	00						31	20	55	08	11

South Declination.

South Declination.

South Declination. | North Declination.

A Table of the Suns Place and Declination.

Days.	April. S. Place. d.	m.	S. Decl. d.	m.	Days.	May. S. Place. d.	m.	S. Dec. d.	m.	Days.	June. S. Place. d.	m.	S. Dec. d.	m.
1	21 ♈	54	8	34	01	20 ♉	58	18	04	01	20 ♊	37	23	12
2	22	53	8	56	02	21	56	18	19	02	21	34	23	16
3	23	51	9	17	03	22	53	18	34	03	22	32	23	19
4	24	50	9	39	04	23	51	18	49	04	23	29	23	22
5	25	48	10	1	05	24	48	19	03	05	24	26	23	25
6	26	47	10	22	06	25	46	19	17	06	25	23	23	27
7	27	45	10	43	07	26	44	19	30	07	26	20	23	29
8	28	43	11	4	08	27	41	19	43	08	27	17	23	30
9	29	42	11	25	09	28	39	19	56	09	28	15	23	31
10	0 ♉	40	11	45	10	29	36	20	09	10	29	12	23	32
11	1	38	12	5	11	00 ♊	34	20	21	11	00 ♋	09	23	32
12	2	37	12	26	12	01	31	20	33	12	01	06	23	32
13	3	35	12	46	13	02	29	20	44	13	02	03	23	31
14	4	33	13	5	14	03	26	20	56	14	03	00	23	30
15	5	31	13	25	15	04	24	21	07	15	03	57	23	28
16	6	29	13	44	16	05	21	21	17	16	04	54	23	27
17	7	27	14	3	17	06	18	21	27	17	05	51	23	25
18	8	25	14	22	18	07	16	21	37	18	06	48	23	22
19	9	23	14	41	19	08	13	21	46	19	07	46	23	18
20	10	21	14	59	20	09	10	21	55	20	08	43	23	15
21	11	19	15	17	21	10	08	22	03	21	09	40	23	11
22	12	17	15	35	22	11	05	22	11	22	10	37	23	06
23	13	15	15	53	23	12	02	22	19	23	11	34	23	01
24	14	13	16	10	24	13	00	22	27	24	12	31	22	56
25	15	11	16	27	25	13	57	22	34	25	13	28	22	50
26	16	9	16	44	26	14	54	22	40	26	14	25	22	44
27	17	7	17	1	27	15	51	22	46	27	15	22	22	38
28	18	5	17	17	28	16	49	22	52	28	16	20	22	31
29	19	2	17	33	29	17	46	22	58	29	17	17	22	24
30	20	0	17	49	30	18	43	23	03	30	18	14	22	17
					31	19	40	23	08					

North Declination. (April)

North Declination. (May)

North Declination. (June)

A Table of the Suns Place and Declination.

Days.	July. S. Place. d.	m.	S. Dec. d.	m.	Days.	August. S. Place. d.	m.	S. Dec. d.	m.	Days.	September. S. Place. d.	m.	S. Dec. d.	m.
01	19 ♋	11	22	09	01	18 ♌	48	15	1[illegible]	01	18 ♍	47	04	27
02	20	08	22	01	02	19	46	14	56	02	19	46	04	03
03	21	05	21	55	03	20	44	14	38	03	20	44	03	41
04	22	02	21	43	04	21	41	14	19	04	21	43	03	17
05	23	00	21	34	05	22	39	14	01	05	22	41	02	55
06	23	57	21	24	06	23	37	13	42	06	23	40	02	33
07	24	54	21	14	07	24	36	13	23	07	24	39	02	08
08	25	51	21	04	08	25	32	13	03	08	25	27	01	45
09	26	48	20	53	09	26	30	12	43	09	26	36	01	22
10	27	46	20	42	10	27	28	12	23	10	27	35	00	58
11	28	43	20	30	11	28	26	12	03	11	28	34	00	35
12	29	40	20	18	12	29	24	11	43	12	26	33	00	11
13	00 ♌	37	20	06	13	00 ♍	22	11	23	13	00 ♎	29	00	13
14	01	35	19	53	14	01	19	11	03	14	01	30	00	36
15	02	32	19	40	15	02	17	10	42	15	02	29	01	00
16	03	30	19	27	16	03	15	10	21	16	03	28	01	23
17	04	27	19	14	17	04	13	10	00	17	04	27	01	47
18	05	24	19	00	18	05	11	09	39	18	05	26	02	10
19	06	21	18	45	19	06	09	09	17	19	06	25	02	34
20	07	19	18	31	20	07	08	08	56	20	07	25	02	57
21	08	16	18	16	21	08	06	08	34	21	08	24	03	21
22	09	13	18	01	22	09	04	08	12	22	09	23	03	44
23	10	11	17	46	23	10	02	07	50	23	10	22	04	08
24	11	08	17	30	24	11	00	07	28	24	11	22	04	31
25	12	06	17	14	25	11	58	07	06	25	12	21	04	54
26	13	03	16	58	26	12	57	06	43	26	13	20	05	17
27	14	01	16	41	27	13	55	06	21	27	14	20	05	40
28	14	58	16	24	28	14	53	05	58	28	15	19	06	04
29	15	56	16	07	29	15	52	05	35	29	16	19	06	27
30	16	53	15	50	30	16	50	05	13	30	17	18	06	49
31	17	51	15	32	31	17	49	04	50					

July: North Declination.
August: North Declination.
September: North Declination. | South Declination.

A Table of the Suns Place and Declination.

Days.	October. S, Place. d.	m.	S. Decl. d.	m.	Days.	November. S. Place. d.	m.	S. Dec. d	m.	Days.	December. S. Place. d.	m.	S. Dec. d.	m.
1	18 ♎	18	7	11	01	19 ♏	21	17	38	01	19 ♐	49	23	08
2	19	17	7	34	02	20	21	17	54	02	20	51	23	13
3	20	17	7	57	03	21	22	18	10	03	21	52	23	17
4	21	16	8	19	04	22	23	18	26	04	22	53	23	20
5	22	16	8	43	05	23	23	18	42	05	23	54	23	23
6	23	16	9	05	06	24	24	18	57	06	24	56	23	26
7	24	15	9	26	07	25	25	19	11	07	25	57	23	28
8	25	15	9	48	08	26	26	19	25	08	26	58	23	30
9	26	15	10	10	09	27	26	19	39	09	28	00	23	31
10	27	15	10	33	10	28	27	19	53	10	29	01	23	32
11	28	15	10	53	11	29	28	20	07	11	00 ♑	02	23	32
12	29	15	11	15	12	00 ♐	29	20	20	12	01	03	23	32
13	0 ♏	15	11	36	13	01	30	20	32	13	02	05	23	31
14	1	15	11	57	14	02	31	20	44	14	03	06	23	30
15	2	15	12	18	15	03	32	20	56	15	04	07	23	29
16	3	15	12	39	16	04	33	20	08	16	05	09	23	27
17	4	15	12	59	17	05	34	21	19	17	06	10	23	24
18	5	15	13	19	18	06	35	21	30	18	07	11	23	20
19	6	15	13	39	19	07	36	21	40	19	08	13	23	16
20	7	16	13	59	20	08	37	21	50	20	09	14	23	12
21	8	16	14	19	21	09	38	21	59	21	10	15	23	08
22	9	16	14	38	22	10	39	22	08	22	11	17	23	03
23	10	16	14	58	23	11	40	22	16	23	12	18	22	57
24	11	17	15	17	24	12	41	22	24	24	13	19	22	51
25	12	17	15	35	25	13	42	22	32	25	14	21	22	45
26	13	18	15	54	26	14	43	22	39	26	15	22	22	38
27	14	18	16	12	27	15	45	22	46	27	16	23	22	31
28	15	19	16	29	28	16	46	22	54	28	17	25	22	24
29	16	19	16	46	29	17	47	22	58	29	18	26	22	15
30	17	19	17	4	30	18	48	23	03	30	19	27	22	07
31	18	20	17	21						31	20	28	21	58

South Declination.

South Declination.

The Uſe of the Foregoing TABLES *of the Suns* Place *and* Declination.

The Table conſiſteth of 12 *Parts*, repreſenting the 12 Moneths of the Year, as appears by the *Titles* at the Head of each *Part*. Then on the left hand of each *Moneth* is ſet the number of Dayes therein contained; as *January* 31 days, *February* 28 days, *&c.* Again, in the other two Columns under each Moneth, the one contains the degrees and minutes of the Zodiack, in which the Sun is at noon, every day in the Year; and the other ſhews the *Suns Declination* from the *Equinoctial* either *Northward* or *Southward* every day at Noon.

Example. I deſire to know the *Suns Place*, and conſequently, his *Declination* upon the firſt day of *January*, Look in the Table for *January*, and againſt the firſt day thereof you ſhall find 21 *Capricorn* 45, in the Column under the *Suns* place, which ſhews, that the Sun, that day at Noon, is in 21 d. and 45 m. of *Capricorn*; and in the next Column under [*S. Decl.*] you ſhall find 21 46, that ſhews that that day, at Noon, the Sun is declined from the *Equinoct. Southw.* 21 d. and 46 m. And thus you may find the Suns Place and Declination for any day in the Year; as,

		d.		m.		d.	m.	
Mar. 16	The Sun will be in	6	*Aries*	12	And his Dec. will be	2	59	N.
May 11		0	*Gem.*	34		20	21	N.
Aug. 27		13	*Virg.*	55		6	21	N.
Oct. 18		5	*Scor.*	15		13	19	S.
Nov. 26		14	*Sag.*	43		22	39	S.

And

And here note, that the Sun never declineth from the *Equinoctial*, Northward or Southward, more than 23 d. 32 m. which is his greateſt Declination; and ſuch Declination he hath, when he enters into *Cancer* or *Capricorn*, which is about the 11 of *June*, and the 11 of *December*, making the longeſt and ſhorteſt days; and when the Sun is in the *Equinoctial*, he hath then no *Declination* at all, and then the Days and the Nights are of equal length throughout the World; and that is about the 10*th*. of *March*, and the 12*th*. or 13*th*. of *September*.

And note further, that from the 10*th*. of *March*, to the 12*th*. or 13*th*. of *September*, the Sun hath *North Declination*, and he is in *Northern Signes*, viz. *Aries*, *Taurus*. *Gemini*, *Cancer*, *Leo* or *Virgo*. And from the 12*th*. or 13*th*. of *September*, to the 20*th*. of *March*, he hath *South Declination*, and he is in ſome of the *Southern Signs*, as in *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius* or *Piſces*. All which is viſible in the *Table*, according to the reſpective *Titles*; and therefore no more need be ſaid concerning it in this place.

Problemes

PANORGANON.

The First Part.

CONTAINING

The Description, Construction and Use of the *INSTRUMENT* in general.

SECT. I.

Of the Circle, Scales and Lines upon the Instrument, their Description and Construction.

THe Instrument differeth not much from a *Quadrant*, only the sides thereof are made somewhat broader; and the Arch comprehended between them is an exact *Quadrant* containing 90 d. The two broad sides (for distinction) I call the *Wings*; and the *Quadrant*, contained between

them, I call the *Quadrantal part of the Instrument.*

The *Wings* of the Instrument must be made of such a competent breadth, as either of them may be capable to receive two Lines at the least to issue from the Center, without incumbring one another; by this means, eight Scales may be inscribed upon the four sides of the two Wings, upon which any man may place such as may best sute with his Fancy or Occasions; and the two Wings of the Instrument thus disposed, having a Quadrant between them, exactly representeth a *Sector* opened to a right Angle; and for this reason, I have placed upon them these Lines, *viz.* upon one Wing,

1. *Equal Parts,*
2. *Squares* or *Superficies.*

And upon the Wing opposite thereunto,

3. Right *Sines.*
4. *Cubes* or *Solids.*

These four Scales are placed upon the two Wings on the foreside of the Instrument; On the two Wings on the backside are

5. Natural *Tangents.*
6. *Versed Sines.*

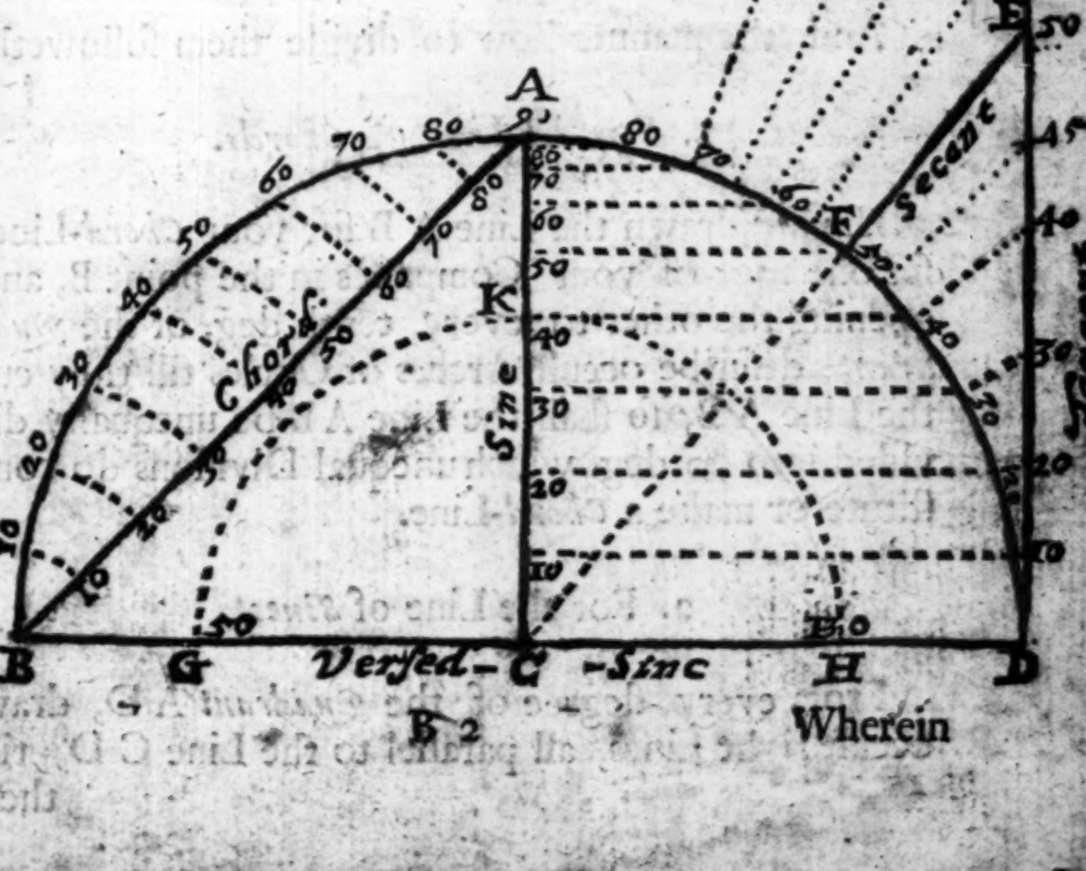
And opposite unto them,

7. Natural *Sines* and *Secants.*
8. *Chords.*

These are such Lines as I conceive most useful; though divers others might be inserted: And for the the construction of them, and inserting of them orderly

derly on the Instrument, it is so well known to all that are Makers of Mathematical Instruments, that I shall say nothing of that in this place; only, in the making of the Instrument, let them be sure to make the *Sines*, *Tangents*, and *Versed Sines*, to the same *Radius*. And it were not amiss, if that in some convenient place of the Instrument (as there may be found places enough) from the Center, a Scale of *equal parts*, a *Tangent* of 45 deg. numbered to 90. (commonly called an *half Tangent*) and a Scale of *Chords* also, were inserted to the same *Radius*, as the *Sines*, *Tangents* and *Secants* are, which will be of excellent use in projection of the Sphear, *&c.*

Now for the sakes of such as are ignorant of the construction of these Scales, I shall adde this Figure:



 Wherein

Wherein let the Line C A be the *Semidiameter*, or *Radius* of any Circle, as here it is of this Semicircle B A D.

The Semicircle being described, divide it into two equal parts or Quadrants by the perpendicular Line C A; then divide each of the Quadrants B A and A D into 90 equal parts or degrees, as in the Figure is done, to every tenth deg.

This done, your Scheme is prepared for the dividing of your Scales of *Sines*, *Tangents*, *Secants*, *Chords* and *Versed Sines*; for,

The Line { C D is a Line of *Sine*.
D E is a *Tangent* Line.
C E is a *Secant*.
A B is a *Chord*, and
B D is a Line of *Versed Sines*. }

And the manner how to divide them followeth.

1. For the Line of *Chords*.

Having drawn the Line A B for your *Chord*-Line, set one foot of your Compasses in the point B, and opening the other to every tenth deg. of the *Quadrant*, describe occult Arches of Circles till they cut the Line A B, so shall the Line A B be unequally divided into 90 deg. which unequal Divisions do constitute or make a *Chord*-Line.

2. For the Line of *Sines*.

From every degree of the *Quadrant* A D, draw occult right Lines, all parallel to the Line C D, till they

they interſect or cut the Line A C, ſo ſhall theſe occult Lines divide the Line A C into 90 unequal parts or degrees, which makes the Scale of *Sines*.

3. For the Line of *Tangents*.

Upon the point D, erect a Perpendicular D E, and through every degree of the *Quadrant* A D, draw right Lines from the Center, till they cut the perpendicular Line D E, dividing that into unequal parts, called *Tangents*.

4. For the *Secants*.

A right Line drawn from the Center of the Circle C, through any degree of the *Quadrant* A D, till it meet with the *Tangent* Line, is called the *Secant* of that degree through which it cutteth in the *Quadrant*. As in the Figure, the right Line C E, paſſing through 50 deg. of the *Quadrant* A D, till it cut the *Tangent-Line* in E, is the *Secant* of 50 deg.

5. For the *Verſed Sines*.

The Line of *Verſed Sines* is no other than two Scales of Sines; wherefore, ſetting one foot of the Compaſſes in the point or Center C, deſcribe occult Semicircles through every degree of the Scale of *Sines* A C, as the Semicircle G K H drawn through 40 deg. of the Line of *Sines*, giveth the point of 50 deg. of the *Verſed Sines* at G, and of 130 d. at the point H, ſo the whole Line B D is a Scale of *Verſed Sines*, beginning at 00 d. at B, 90 d. at C, and ending at 180 d. at E.

And this may serve for the *Definition* and *Geometrical construction* of these Lines; and the like might have been done for the Lines of *Squares* and *Cubes*; but the best way to divide the Scales of *Sines*, *Tangents*, *Secants* and *Chords*, is from the Tables of Natural *Sines*, *Tangents* and *Secants*; and the Lines of *Squares* and *Cubes* are best divided from Tables of the *Square* and *Cube Roots*. The manner how to apply those Tables to the transferring of the Lines upon the Instrument, is so well known, and the Tables themselves in every mans hands, that it were needless here, either to insert the Tables, or say any thing more concerning the Lines on the Wings of the Instrument, only in the spare places between the general Lines, other Lines more particular (as of *Equated Bodies*, *Segments* of *Circles* or *Sphears*, *Metals*, *Inscribed Bodies*, of *Quadrature*, &c.) may be inserted, in the void places, between the general Lines before-mentioned: And if the Wings of the Instrument be made broad enough, more Lines than two upon one Wing may be made to issue from the Center; but the eight forementioned being the most useful and necessary, I shall only exemplifie in them; any other Lines whatsoever, that are described upon any *Sector* whatsoever, may be inserted into this, and their uses also applied hereunto. And now shall follow,

The Description of such Lines as are inscribed on the Quadrantal Part of the Instrument.

The Quadrantal part of the Instrument consisteth of two sides, *viz.* The *Foreside* and the *Backside*: The *Foreside* is some part of a Projection of the Sphear *in plano*,

plano, and ſome other Scales; and the *Back-ſide* conſiſts only of ſeveral concentrick Circles, in which are placed ſeveral circular Scales, principally relating to the Motions of the *Fixed Stars.*

I. *The Deſcription of the Lines, and the Conſtruction of the Foreſide of the Inſtrument.*

Between the two Wings of the Inſtrument is left an exact *Quadrant*, the Limb whereof is divided into 90 equal degrees, and ſubdivided into parts, according to the largeneſs of the Inſtrument, and numbred by 10, 20, 30, &c. (from the left hand towards the right) to 90 deg. after the uſual manner. And within the Superficies, is deſcribed a part of that projection of the Sphear, which is uſually known by the name of the *ANALEMMA*; and the manner how to draw this Projection, for any Latitude or Latitudes, is as followeth.

Firſt, Leaving ſome convenient ſpace for the deſcribing of two Circular Arches, for the inſcription of the *Moneths*, and *Dayes* of the *Moneths*, deſcribe an occult arch of a Circle, as A B; and laying a Ruler from O, the Center of the Inſtrument, to 60 deg. (or to any other more convenient number of deg. which may be more ſutable to the Latitude of the place for which you make your Inſtrument, as 60 d. is moſt ſutable for thoſe middle Latitudes which I have here made choice of) draw a right Line O C, which line may be called *The Line of the Suns Altitude*, or *Line* of 60, and may be divided from C towards O, as a Line of Sines is divided.

Secondly, Conſider what Latitude or Latitudes you would

would insert into your Instrument (as I have inserted in this Instrument, in the Figure, all the Latitudes from 46 deg. to 54 deg. which will serve all the principal Places in *Europe*, and more might be inserted.) But for Instance; Suppose I would insert the Latitude of *London* 51 deg. 30 m. count the Complement thereof 38 deg. 30 min. upon the Limb of the *Quadrant* from 60 deg. towards the left hand, and from the Center of the *Quadrant*; thereto lay a Ruler, so shall it cut the Arch formerly drawn in D, and a right Line drawn from D, perpendicular to the Line of the Suns Altitude, or Line of 60, as the Line D E, (which Line D E must be continued so far beyond the Line of 60, till it meet with a Line drawn from the Center O, to 23 d. 30 m. counted in the Limb from 60 d. towards the right hand) and this shall be the Line representing the Latitude of 51 deg. 30 m. And the like may be done for any other Latitude.

Thirdly, For the division of this Line of the Latitude of *London*, (or of any other deg. of Latitude) it is to be divided, in all respects, as a Line of Sines is divided, beginning at the Line of 60, and numbering of it, as in the Figure; that is to say, from the left hand towards the right, by 10, 20, 30, *&c.* to 120, and farther, or not so far, as the Latitude of the place shall require, for the counting of the *Azimuths*: And the same Divisions will serve for the dividing of the Hours, which are numbered from the left hand towards the right, by 1, 2, 3, 4, 5, 6, 7, 8, representing the hours of the Afternoon; and back again by IV, V, VI, VII, VIII, IX, X, XI, XII, representing the hours of the Forenoon; each hour being sub-divided into 15 unequal parts or degrees; each

part

part or degree containing 4 minutes of time: Or, each hour may be divided into Halves, Quarters and half Quarters, according to the mind of him that is to use it. And if there be several Latitudes put into one Instrument, as here is from 46 to 54 deg. of Latitude, then it were necessary (at the two extream Latitudes) to draw Marginal Lines, one above the lesser Latitude, and the other beneath the greater Latitude, the one, wherein to set the numbers of the hours, which may be called the *Line of Hours*, and the other, wherein to set the numbers of the *Azimuths*, and may be called the *Azimuth Line*.

Fourthly, Count 23 deg. 30 min. (the Suns greatest declination) from 60 deg. in the Limb, on either side thereof, and from the Center O, thereto lay a Ruler, which shall cut the circular Arch formerly drawn, on the right hand of 60, at the point ♋, and on the left hand of 60, at the point ♑ so a right Line drawn from these two points *Cancer* and *Capricorn*, shall be called the *Zodiack*; (and this *Zodiack* is also the line for the Latitude of 23 deg. 30 min. though it be generally to be used with all other Latitudes, as in the following Uses will appear.)— For the dividing of this *Zodiack-Line*, it is to be divided in all respects as a Line of Sines is divided; but the numbering thereof is different; for it representing the *Zodiack*, is divided into 12 parts, answerable to the 12 Signes, and is numbered from the middle thereof, towards the right hand.

Thus	Above the line	♈ 10 20 ♉ 10 20 ♊ 10 20 ♋
	Under the line	♎ 20 10 ♍ 20 10 ♌ 20 10.

C

And

And from the middle thereof towards the left hand,

Thus	Above the line	♑	10 20 ♒ 10 20 ♓ 10 20.
	Under the line		20 10 ♐ 20 10 ♏ 20 10.

Fifthly, This Scale or *Zodiack* is contained between 23 deg. 30 min. and 23 deg. 30 m. on either side of the line of 60. So that the 23 deg. 30 m. of the Limb, which lieth on the right hand, are to be counted as the 23 deg. 30 m. of the Suns *North Declination*, and the 23 deg. 30 m. on the left hand, are to be counted as the degrees of the Suns *South Declination*: and may be called the *Scale of the Suns Declination*.

Sixthly, Between the Limb of the *Quadrant*, and the Circular Arch before drawn, are described two Circles, containing the Moneths, and Dayes of each Moneth in the year, *viz.* In the uppermost is inscribed one half of the year, namely, the *Spring* and *Summer* Quarters, containing part of *December*, all *January*, *February*, *March*, *April*, *May*, and part of *June*; and the undermost contains the *Autumnall* and *Winter* Quarters; namely, part of *June*, all *July*, *August*, *September*, *October*, *November*, and part of *December*. These two Circles are called the *Circles of Moneths*, and the manner how to divide them is sufficiently known; for they may be divided by Tables of the Suns declination, from the Scales of the Suns Declination; or from Tables of the Suns place, from the *Zodiack-line*: This is so well known, and the Tables so common, both in this and other Books, that it were needless to say more concerning it.

Thus have you a Deſcription of the General Lines which are inſcribed upon the *Quadrantal part* of the foreſide of the Inſtrument: Wherein you are to obſerve, that if you are to inſert never ſo many lines of Latitudes, they muſt all of them be divided as if they were ſo many ſeveral lines of Sines; but inſerting many Latitudes together (as here I have done, for 9 or 10 ſeveral degrees of Latitude) the ſeveral Lines may be divided by Arches of *Ellipſes* (eſpecially for every 5th. degree) and the intermediate diviſions by Pricks only, which will not only be eaſie to deſcribe, but very pleaſant and ready to count by; and the hour-points of 12, and Azimuths of 00 deg. in all Latitudes, will be a perfect Circle; the Hours of ſix, and Azimuths of 90 deg. will be a ſtraight line, and all the other, Elliptical Arches; and are left to be ſo deſcribed.

Beſides theſe Lines before deſcribed, there are other Lines: As,

1. A *Line of three Hours*, placed near to one of the Wings of the Inſtrument, which is no other than a Tangent line of 45 deg. made to half the *Radius* of the Inſtrument; and may be divided by a Table of Natural Tangents, into the Degrees and Minutes belonging to the Quarters, Halves, Three Quarters, and whole Hours. It ſtandeth neer to the right wing of the Inſtrument, and is divided firſt into 3 unequal parts, marked with ***, repreſenting whole hours; then either of theſe three parts is divided into two other unequal parts, marked with little ſhort lines, thus, | | |, repreſenting half hours: And again, every of theſe parts is divided into two other unequal parts, by points only; as - - - - - -, repreſenting quarters of hours.

hours. This Scale is called the *Scale of three Hours*.

2. Besides this Line of Three Hours, there is another Line, called the *Latitude-Line*, which Line contains the numbers of the Complements of such degrees of Latitude as are inserted in the Instrument; which Line may be made to every degree of Latitude, and that in this manner:

Make the Hour or Azimuth-Scale belonging to each particular Latitude, a several *Radius*, or 1000 parts. The several points in the Latitude-line from 36 to 54, are the Natural Tangents of the Complements of those Latitudes; as the Natural Tangent 726 giveth the point of 36 deg. of Latitude in the Line of Latitudes, its Complement 54 deg. of Latit. being made the *Radius*, and the rest as in the Table following.

A Table for the dividing of the Latitude-Line.

Degr. of Latitude	Natural Tangents.	Degr. of Latitude.	Natural Tangents.
36	1 - 376	45	1 - 000
37	1 - 327	46	0 - 965
38	1 - 279	47	0 - 932
39	1 - 234	48	0 - 800
40	1 - 191	49	0 - 869
41	1 - 150	50	0 - 839
42	1 - 110	51	0 - 810
43	1 - 072	52	0 - 781
44	1 - 053	53	0 - 753
		54	0 - 726

This

This Table of Latitudes may easily be continued to any other degr. of Latitude, even from the Equinoctial to the Pole, and may be set in any spare place upon the Instrument; but best, and most readiest, near to one of the Wings. And thus have you a Description of all the Lines on the foreside of the Quadrantal part of the Instrument.

II. *The Description of the Circles on the Back side of the Quadrantal Part.*

Next, above the equal Limb of 90 degr. there is,

1. A Circle of *Right Ascensions in Time*, the whole *Quadrant* being divided into 24 equal parts, signifying hours, and numbered from the left towards the right hand, by 1, 2, 3, 4, *&c*, to 12 in the middle; and then forward forward from the middle 12, by 1, 2, 3, *&c*. to 12 at the end; the 12 in the middle signifying 12 at Midnight.

2. There is a Circle of *Right Ascensions in Degrees and Minutes*, the *Quadrant* being divided into 360 deg. one degr. of the equal Limb being equal to some of these, it is numbered from the right hand towards the left, by 10, 20, 30, *&c*. to 360. This Circle is useful to convert Degr. and Minutes of the Equinoctial into Hours and Minutes of Time.

3. An *Ecliptick*, having at every 30th. deg. of the Circle of *Right Ascensions*, the Characters of one of the *Signs*, as at the beginning, towards the right hand, is *Aries*; 30 deg. forwarder is *Taurus*; and 30 deg. forwarder, *Gemini*, &c.

4. Above this Circle is a small Margin, having in it only the *Characters* of such *Stars* as are placed in the Instrument.

5. The

5. The *Names of those Stars*, and are inserted according to their *Right Ascensions*.

6. Above the Names, is set the *Declinations* of those Stars. And,

7. Their *Magnitudes*,

The Stars placed in the Instrument, may be any, either such as are in the Table at the end of this Book, or such others as are best known or desired by the User of the Instrument. And being there is some spare place between these Circles and the Center of the Instrument (such as desire it) may have there inserted such hour-Lines as are usually drawn upon Mr. *Gunter's* Quadrant; for that they give the Hour more readily (though not so exactly) as the Scales on the other side of the Instrument.

And thus have you a particular account of the several *Lines*, *Scales* and *Circle* inscribed upon the whole Instrument; to which also there belongeth two *Sights*, a *Thred* and *Plummet*, as is usual in all *Quadrants*. But besides the ordinary Line and Plummet, which may be made to hang excentrick to the Center of the *Quadrant*, on the backside, I would have a very fine Hair, Silk, or Wire, to go quite through the Center of the Instrument, and be fastned at either end to a piece of Brass, having a Groove in it equal to the Limb of the *Quadrant*, and in that Groove a Spring, which may at all times keep the String straight from the Center of the *Quadrant*; and being moved along, may stand fixed in any position whatsoever. This Groove may be turned

aside

aside under one of the Wings of the Instrument, at any time, when you are to take the *Altitude* of the *Sun* or *Stars*; so that it may not hinder the motion or playing of the other Thred and Plummet, which is to be put on and taken off at pleasure; but the other would be constantly fixed.

And thus much shall serve for the Description; now shall follow the Uses of the Instrument.

SECT.

SECT. II.

Of the General Use of the Instrument, and the manner of working upon it.

THe Instrument being made and fitted as is before directed, the Wings thereof do exactly represent a *Sector* opened to a right Angle, and the motion of the Thred between the two Wings, do make it a *Sector* opened to any Angle less than a right Angle; by which means, all Proportions may be wrought by it, as well as by a *Sector*; and altogether as *exactly*, *easily*, and more *expeditiously* than by the *Sector*; whether the *Proportion* to be wrought, be to be performed upon one single Line, or upon two or more Lines; and whether the *Proportion* be *Direct* or *Reciprocal*.

For the manner of working upon the Instrument in general, these things are to be considered.

1. *The manner how to dispose the Terms of the Proportion:* And,
2. *The Terms being truly disposed, how to apply them to, and work them upon the Instrument.*

And for the Disposition of the Terms;

1. If the 4 Terms be all of one kind, or denomination,

nation, ſo as the firſt is to the ſecond, as the third may be to the fourth.

2. But to diſpoſe the Terms of a Proportion of different kinds, you are ſo to order them (as near as you can) that the *firſt* and the *third* may be of one kind, name, or denomination ; and the *ſecond* and *fourth* Terms of another.

The Terms being diſpoſed, to know upon what Scale your work muſt be performed, when they are of different kinds ;

Compare the two firſt Terms of your Proportion together, and find which of them is them is the longeſt (which you may do by meaſuring each of them upon his proper Scale) and upon that Scale which belongeth to the longeſt Term, muſt the Proportion be performed,

☞ The Terms being diſpoſed, and the Scale upon which the Proportion is to be wrought, known ; the manner of working upon the Inſtrument, will be twofold: And for the two different manners of working, obſerve theſe two *General Rules*.

If the *SECOND TERM* be

- *LESSER* than the Firſt,

  Take the *Second Term* out of its proper Scale, and ſet that diſtance in the point of the *Firſt Term*, bringing the Thred to the neareſt diſtance. Then from the point of the *Third Term*, take the neareſt diſtance to the Thred ; and this diſtance meaſured upon the Scale, from whence the *Second Term* was taken, ſhall give the *Fourth Term* required.

  And this is called *LATERAL* Entrance.

- *GREATER* than the Firſt,

  Take the *Firſt Term* out of its proper Scale, and ſet that diſtance in the point of the *Second Term*, bringing the Thred to the neareſt diſtance. Then take the *Third Term* out of its proper Scale, and (with that diſtance) move one foot of the Compaſſes gently along the Line, till the other, being turned about, may only touch the Thred ; ſo ſhall the Compaſs-point reſt in the *Fourth Term* required.

  And this is called *PARALLEL* Enterance.

Thus

Thus have you the wayes of working, and the difference, or distinction, between *Parallel* and *Lateral Enterance*; the Ground and Reason whereof is demonstrated in the second and fourth *Prop.* of the 6th. of *Euclide*, and needs not here be repeated; for, in this Treatise I do not design *Demonstration*, but *Practice*. And that what is now last delivered, may the more evidently appear (for in the following Examples I intend to avoid Circumlocutions) I will adde a plain Scheme, with an example of each kind wrought upon it.

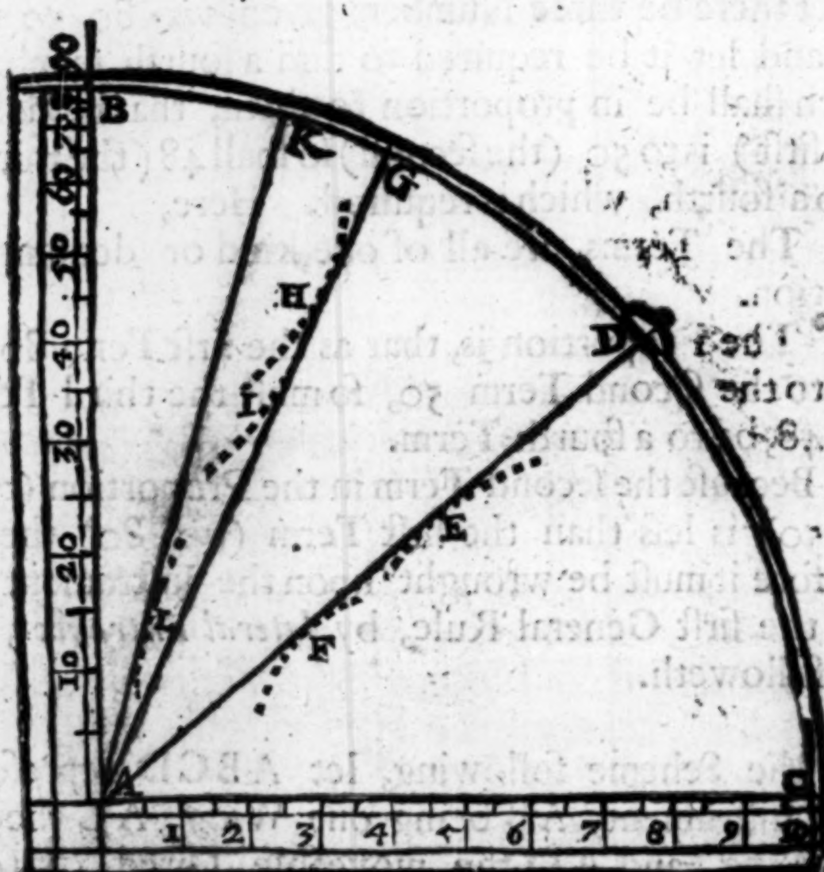
Example 1.

Let there be three Numbers given, *viz.* 80, 50 and 48. and let it be required to find a fourth number, which shall be in proportion to them, that is, as 80, (the first) is to 50 (the second) so shall 48 (the third) be to a fourth, which is required. Here,

1. The Terms are all of one kind or denomination.
2. The Proportion is, that as the first Term 80, is to the second Term 50, so must the third Term 48, be to a fourth Term.
3. Because the second Term in the Proportion (*viz.* 50) is less than the first Term (*viz.* 80) therefore it must be wrought upon the Instrument by the first General Rule, by *lateral Entrance*; as followeth.

In the Scheme following, let ABCD represent your Instrument, AB being one Wing, AC the other Wing, and AD the moveable Thred. Upon

the Wing A B is a Line of Sines, and upon the Wing A C is the Line of equal parts; upon which this proportion is to be wrought: Wherefore, the second term in the Proportion, being less than the first (according to the first general Rule) I take the second term (50) out of the Scale of equal Parts, and setting that distance in (80) the second term, I turn the other foot of the Compasses about, making a representative Arch, as E, till I bring the Thred A D only to touch the moveable point of the Compasses, and there let the String rest (for it is fixed for this proportion.) Then setting one point of the Compasses in the third Term (48) I turn the other foot about, till



it

it only touch the Thred, making a repreſentative Arch, as at F. Laſtly, This diſtance of the Compaſſes meaſured upon the Line of equal parts, will reach from the beginning thereof, to 30; ſo that 30 is the fourth proportional term required; for,

As 80 is to 50 : : ſo is 48 : to 30.

Example 2.

But if the three proportional terms given, had been 50. 80. 30. then the Proportion muſt have been wrought according to the ſecond General Rule, by *Parallel Entrance*, as followeth.

Here, (becauſe the ſecond term is greater than the firſt, I take the firſt term (50) out of the Scale of equal parts, and ſetting one foot in the point of the ſecond term (80) I bring the Thred to the neareſt diſtance. Then out of the Scale, I take the third term (30) and with this diſtance of the Compaſſes, I move one foot thereof gently along the Scale of equal parts, till the other, being turned about, it may only touch the Thred, as by the Arch F in the Scheme is repreſented; and ſo you ſhall find the point of the Compaſſes to reſt in 48, which is the fourth proportional term required. For,

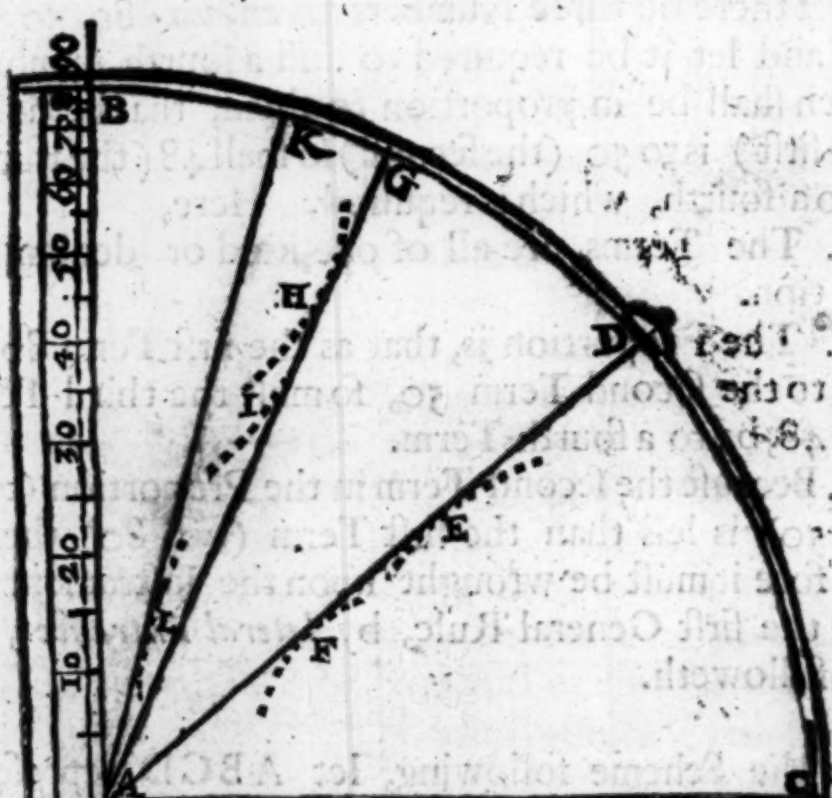
As 50 : is to 80 : : So is 30 : to 48.

This is very plain: And the like is to be done in all caſes, where the four terms be all of one kind, name or denomination. And if they be of different kinds, then the following Examples will make that plain alſo.

Wherefore let us take an Example in *Sines* and *equal Parts*, which are Terms of different denominations.

Example

the Wing A B is a Line of Sines, and upon the Wing A C is the Line of equal parts; upon which this proportion is to be wrought: Wherefore, the ſecond term in the Proportion, being leſs than the firſt (according to the firſt general Rule) I take the ſecond term (50) out of the Scale of equal Parts, and ſetting that diſtance in (80) the ſecond term, I turn the other foot of the Compaſſes about, making a repreſentative Arch, as E, till I bring the Thred A D only to touch the moveable point of the Compaſſes, and there let the String reſt (for it is fixed for this proportion.) Then ſetting one point of the Compaſſes in the third Term (48) I turn the other foot about, till



it only touch the Thred, making a repreſentative Arch, as at F. Laſtly, This diſtance of the Compaſſes meaſured upon the Line of equal parts, will reach from the beginning thereof, to 30; ſo that 30 is the fourth proportional term required; for,

As 80 is to 50 : : ſo is 48 : to 30.

Example 2.

But if the three proportional terms given, had been 50. 80. 30. then the Proportion muſt have been wrought according to the ſecond General Rule, by *Parallel Entrance*, as followeth.

Here, (becauſe the ſecond term is greater than the firſt, I take the firſt term (50) out of the Scale of equal parts, and ſetting one foot in the point of the ſecond term (80) I bring the Thred to the neareſt diſtance. Then out of the Scale, I take the third term (30) and with this diſtance of the Compaſſes, I move one foot thereof gently along the Scale of equal parts, till the other, being turned about, it may only touch the Thred, as by the Arch F in the Scheme is repreſented; and ſo you ſhall find the point of the Compaſſes to reſt in 48, which is the fourth proportional term required. For,

As 50 : is to 80 : : So is 30 : to 48.

This is very plain: And the like is to be done in all caſes, where the four terms be all of one kind, name or denomination. And if they be of different kinds, then the following Examples will make that plain alſo.

Wherefore let us take an Example in *Sines* and *equal Parts*, which are Terms of different denominations.

Example

Example 3.

Let the Terms of the Proportion be,
As Sine 60 d. to the numb. 35 : : So Sine 48 d. to what Number?

The first and second Terms are, Sine 60 d. and Number 35.

Now to know which of these two is the greatest; If you take 60 deg. out of the Line of Sines, you shall find it to be much longer than 35 of the equal parts; which shews that the proportion must be wrought upon the Scale of Sines.

And the second Term being less than the first, shews also, that it must be wrought by the first General Rule. Wherefore,

Take the second Term (35) out of the Scale of equal parts, and setting one foot of that extent in the second Term 60 deg. of the Signes, bring the Thred A G to the nearest distance (as at the Arch H,) and there let it rest: Then from the third Term (Sine 48 d.) take the nearest distance to the Thred (as at the Arch I) which distance being measured upon the Scale of equal parts, will reach from the beginning thereof to 30; so that the Number 30 is the fourth proportional Term: For,

As S. 60 d. is to N. 35 : : So is S. 48 d. to N. 30.

But to frame an Example that may fall under the second General Rule: Which, let be this.

Exam-

Example 4.

Let the Terms of the Proportion be
As S. 60 d. to N. 90: So the S. of 48 d. to what Number?

Here by trial you ſhall find that the Number 90, (the ſecond Term) is greater than the Sine 60 d. (the firſt Term) and therefore the Proportion muſt be wrought upon the Line of equal parts; and the ſecond Term being greater than the firſt, it muſt be wrought by the ſecond General Rule. Wherefore, take 60 d. out of the Line of Sines, and ſetting one foot of that extent in 90, the ſecond Term, bring the Thred K to the neareſt diſtance, as at L, and there let it reſt; then from the Line of Sines, take the third Term (48 d.) and with this diſtance, move one foot of the Compaſſes along the Line of equal parts, till the other, being turned about, may only touch the Thred; and then will the Compaſs-point reſt upon the Line of equal parts, at $77\frac{1}{5}$, which is the fourth Proportional Number. For,

As S. 60 d. is to N. 90. So is S. 48 d. to N. $77\frac{1}{5}$.

Thus have you the ſeveral various wayes of working upon the Inſtrument; and theſe 4 Examples well underſtood, nothing that is to follow, will be difficult; for whatſoever before was done in equal parts alone, the like may be done, (and the ſame Rules are to be obſerved) in *Sines*, *Tangents*, *Squares*, *Cubes* alone alſo. And what is done in *Sines* and *equal parts*, the like may be done (with the ſame Cautions) in *Tangents* and *equal parts*.

Tangents

Tangents and *Sines.*
Sines and *Tangents.*
Equal Parts and *Squares.*
Squares and *Cubes.*
Cubes and *Equal Parts*, &c.

And having thus laid the Foundation, I ſhall now proceed to Examples of divers kinds, uſing all Brevity, and as much perſpicuity as may be.

SECT.

SECT. III.

Shewing some Uses of the Line of EQUAL PARTS; singly in Arithmetick *and* Geometry.

I. *In* Arithmetick.

Prob. 1.

To perform Multiplication *by the Line of Equal Parts.*

AS the *Multiplicand* is to the *Multiplier* (or the contrary) so is *One* (or *Unity*) to the *Product.*

The RULE.

Take the lesser of the two Numbers to be multiplied, out of the Line, and with that distance of the Compasses, set one foot in the Term of the greater Number; and bring the Thred to the nearest distance: Then from 10 *at the end of the line, take the nearest distance to the Thred; this distance shall reach from the beginning of the line to the Product of those two Numbers being multiplied together.*

 Example.

Example.

Let it be required to multiply 83 by 56.

Out of the Line, take 56, and with that distance, setting one foot of the Compasses in 83, bring the Thred to the nearest distance; then from 10 at the end of the Line, take the nearest distance to the Thred, so shall that extent of the Compasses reach from the beginning of the Line to 4648, which is the Product of 83, being multiplied by 56.

Prob. 2.

To perform Division *by the Line of Equal Parts.*

As the *Dividend* is to the *Divisor* (or the contrary) so is *One* (or *Unity*) to the *Quotient.*

The RULE.

Add (in your mind) to the Divisor *so many Cyphers as may make it to be of equal number of places with the* Dividend, *and then consider whether the* Dividend *or the* Divisor *be the greater Number; so taking the lesser Number out of the line, set that extent in the Term of the greater, bringing the Thred to the nearest distance; then the nearest distance taken from* 10 *at the end of the Line, to the Thred, being measured upon the Line, shall there shew the* Quotient.

Example

Example 1.

Let it be required to divide 4648 by 83.

Here 4648 is *Dividend*, and 83 the *Divisor*; to which add two Ciphers (in mind) it makes it 8300, which is greater than the *Dividend* 4648; wherefore by the Rule,

Take 4648 (the *Dividend*) out of the Line, and set it in 83 (the *Divisor*) bringing the Thred to the nearest distance; then from (10 at the end of the Line) take the nearest distance to the Thred; that extent measured upon the Line, shall reach (from the beginning thereof) to 56, which is the *Quotient*. But,

Example 2.

Let it be required to divide 864 by 27.

To 27, suppose a Cipher to be added, to make it of equal number of places with 864; then 27 (or 270) being the lesser number, take it out of the Line, and set it in the Term of 864, bringing the Thred to the nearest distance; then take the nearest distance from 10 at the end, to the Thred, and that extent measured upon the Line, shall reach from the beginning thereof to 32, which is the *Quotient*.

Prob. 3.

To work the Rule of Three (*or* Rule of Proportion) *commonly called the GOLDEN RULE, by the Line of EQUAL PARTS.*

This is no other than what hath been formerly delivered in the General manner of working upon the Instrument; but for more variety, take these following Examples.

Example 1.

If 23 *Shillings will buy* 40 *Quarts of Liquor of any kind, how many Quarts will* 53 *Shillings buy?*

Here the second Term is greater than the first; therefore by the second *General Rule*,

Take in your Compasses out of the Line the first Term (23) and set it in the Term of the second (40) bringing the Thred to the nearest distance. Then take out of the Line, the third Term (53) and moving the Compass-point along the Line, till the other foot touch the Thred, the Compass-point shall rest in 92 and $\frac{1}{8}$, and so many Quarts will be bought for 53 Shillings.

As 23 sh. is to 40 Qu. : : So is 53 sh. : to 92 $\frac{1}{8}$ Qu.

Example 2.

If when a Board is 12 *Inches broad, it shall require* 12 *Inches in length to make a Square Foot; how many Inches*

Inches in length ſhall make a ſquare foot when the Board is 16 *Inches broad?*

Here the firſt and ſecond Terms are equal; wherefore, take either of them (*viz.* 12) out of the Line, and in the point 16, ſet the Compaſſes, and bring the Thred to the neareſt diſtance; then take the neareſt diſtance from 12, to the Thred; and that, meaſured upon the Line, ſhall give 9 for the number of Inches which ſhall make a ſquare foot when the breadth is 16 Inches.

Example. 3.

If 20 *Workmen will do any piece of Work in* 80 *weeks time, how many muſt be employed to do the ſame in* 30 *weeks?*

Take 20 out of the Scale, and ſet it in the Term of 30, bringing the Thred to the neareſt diſtance; then from 80, take the neareſt diſtance to the Thred, and that ſhall reach from the beginning of the Line to 93 $\frac{1}{3}$; and ſo many men muſt be employed to do the ſame piece of Work in 30 weeks.

Example 4.

If 72 *Crowns will pay* 54 *Souldiers; how many Souldiers will* 95 *Crowns pay?*

As 72 Cr. is to 54 So.:: So is 95 Cr. to 71 $\frac{1}{4}$ Sould.

Take 54 out of the Line, and ſet it in the Term of 72, bringing the Thred to the neareſt diſtance; then from 95, take the neareſt diſtance to the Thred; that extent meaſured upon the Line, ſhall reach from the beginning thereof to 71 and a quarter; and ſo many Souldiers will 95 Crowns pay.

Exam.

Example 5.

If 400 *l. in 6 Moneths time, will gain* 12 *l. how much shall* 650 *l. gain in the same time?*

As 400 *l.*: to 12 *l.*:: So 650 *l.*: to 19 *l.* 10 *s.*

Take 12 out of the Line, and set it in the Term of 400, bringing the Thred to the nearest distance; then from 650, take the nearest distance to the Thred; that distance measured upon the Line, shall reach from the beginning thereof, to 19 and a half; or to 19 *l.* 10 *s.* and so much will 650 *l.* yield in 6 Moneths.

Infinite Examples of this kind might be proposed; but these are sufficient to shew what may be done by the Line; and any person may frame Questions of his own at pleasure. And what is here said of the simple Rule of Proportion, the like may be done in the double (or compound Rule) at two Operations.

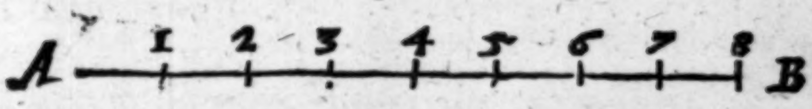
II. *In* Geometry.

Prob. 4.

A Right Line being given, how to divide the ſame into any Number of Equal Parts.

SUppoſe the Line A B were a Line given, to be divided into 8 equal parts:

Take in your Compaſſes the length of the Line given, and ſetting one foot of that extent in the point 8, upon the Line of equal parts (which is the number of parts into which the Line is to be divided) and bring the Thred to the neareſt diſtance; then from the point 1, upon the Line, take the neareſt diſtance to the Thred, and that diſtance ſhall divide the Line A B into 8 equal parts in the points 1, 2, 3, 4, 5, 6, 7, 8.



But (becauſe the point 1, falls near the Center of the Inſtrument) it may be found ſomewhat inconvenient to take the neareſt diſtance from it to the Thred; you may therefore take the neareſt diſtance to 7, (which is one part leſs than the number of parts into which the Line is to be divided, and the neareſt diſtance

ſtance from thence to the Thred, ſhall reach from A to 7; and ſo B 7, is one 8th. part of the Line A B.

In the ſame manner may a Line be divided into any other number of equal parts.

As, if you would divide a Line into 12 equal parts; here (becauſe the parts exceed 10, the number of the Line upon the Inſtrument) take the half thereof, *viz.* 6. Then take the Line given in your Compaſſes, and ſet it in any point upon the Line, that will divide 12 into equal parts without any remainer; as 4 will divide 12 into 3 equal parts, 3 will divide 12 into 4 equal parts, and 6 will divide 12 into 2 equal parts, without any remainer. Set the Sign given in the point 10 at the end of the Line, and bring the Thred to the neareſt diſtance; then if you take the diſtance between 5 and the Thred, that ſhall divide the Line into 2 equal parts, and that diſtance ſet in 6, and the Thred brought to the neareſt diſtance, the neareſt diſtance between 1 and the Thred, ſhall give you $\frac{1}{12}$ of the whole Line; but it will be better to take the neareſt diſtance between 5 and the Thred, and that ſhall give 5 parts, which will be ſufficient to divide your Line by.

ob.

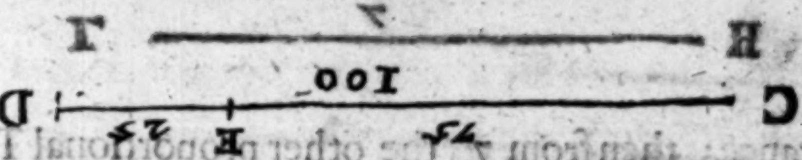
Prob. 5.

To lay down a Line representing any part or parts of a given Line.

Example.

Let the Line C D be a Line containing 100 equal parts of some unknown Scale, and I would find the point of 75 of those parts.

Take the Line CD in your Compasses, and setting one foot in 10 (or 100) at the end of the Line, bring the Thred to the nearest distance; then from 75 to the Thred, take the nearest distance, and that length shall reach from C to E; so shall



CE contain 75 such parts, of which the whole Line CD is 100.

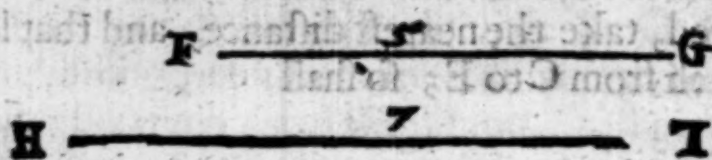
Prob. 6.

To increase or diminish a Line according to any proportion given.

Example 1.

Let F G be a Line given, and let it be required to increase the same in such proportion as 5 is to 7.

Take the Line F G in the Compasses, and setting one foot in the Term 5, bring the Thred to the nearest



distance; then from 7 (the other proportional Term) take the nearest distance to the Thred, and that distance shall be the Line H I, and so is the Line F G increased in proportion, as 5 is to 7, by the Line H I.

Example 2.

But if it were required to diminish the Line H I in such proportion as 7 is to 5. Then,

Take the Line H I in the Compasses, and setting one foot in 7, bring the Thred to the nearest distance; then from 5 to the Thred, take the nearest distance; so shall that distance give the Line F G, and the Line H I is diminished in proportion as 7 is to 5, by the Line F G.

Prob.

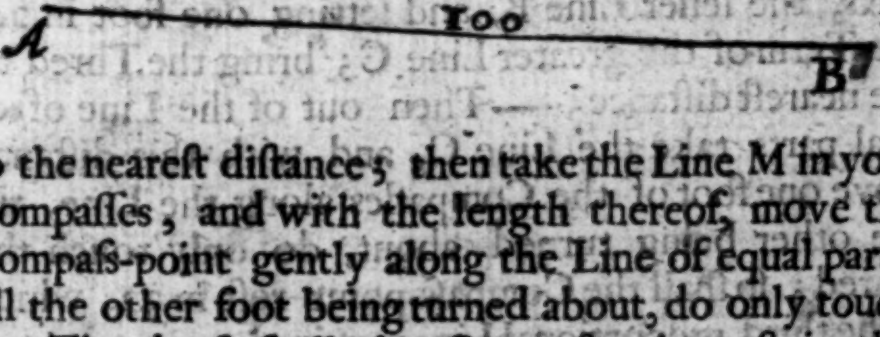
Prob. 7.

Between two or more right lines given, to find a Proportion,

Example.

Let K L and M be three right Lines, and let it be required to find what proportion either of them have to the Line A B, which is 100 parts.

Take the Line A B in your Compasses, and setting one foot of that extent in 10 (or 100) bring the Thred



to the nearest distance; then take the Line M in your Compasses, and with the length thereof, move the Compass-point gently along the Line of equal parts, till the other foot being turned about, do only touch the Thred; so shall the Compass-point rest in the point of 7 (or 70) so is the Line M in proportion to the Line A B, as 100 is to 70. Do the like with the

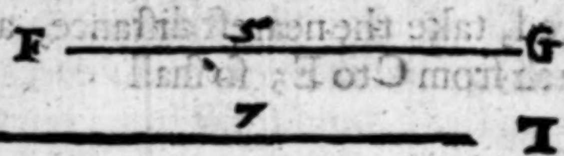
Prob. 6.

To increaſe or diminiſh a Line according to any proportion given.

Example 1.

Let F G be a Line given, and let it be required to increaſe the ſame in ſuch proportion as 5 is to 7.

Take the Line F G in the Compaſſes, and ſetting one foot in the Term 5, bring the Thred to the neareſt



diſtance; then from 7 (the other proportional Term) take the neareſt diſtance to the Thred, and that diſtance ſhall be the Line H I, and ſo is the Line F G increaſed in proportion, as 5 is to 7, by the Line H I.

Example 2.

But if it were required to diminiſh the Line H I in ſuch proportion as 7 is to 5. Then,

Take the Line H I in the Compaſſes, and ſetting one foot in 7, bring the Thred to the neareſt diſtance; then from 5 to the Thred, take the neareſt diſtance; ſo ſhall that diſtance give the Line F G, and the Line H I is diminiſhed in proportion as 7 is to 5, by the Line F G.

Prob.

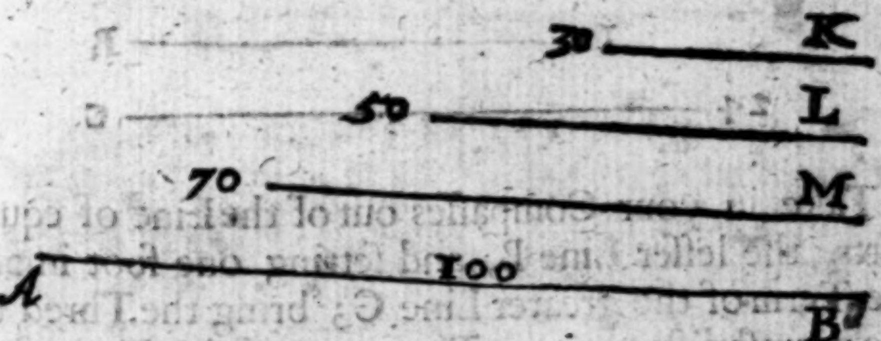
Prob. 7.

Between two or more right lines given, to find a Proportion,

Example.

Let KL and M be three right Lines, and let it be required to find what proportion either of them have to the Line A B, which is 100 parts.

Take the Line AB in your Compasses, and setting one foot of that extent in 10 (or 100) bring the Thred



to the nearest distance; then take the Line M in your Compasses, and with the length thereof, move the Compass-point gently along the Line of equal parts, till the other foot being turned about, do only touch the Thred; so shall the Compass-point rest in the point of 7 (or 70) so is the Line M in proportion to the Line AB, as 100 is to 70. Do the like with the

 other

other Lines; so shall the Line L rest in 50, and the Line K in 30; and such proportion shall the Lines K L and M have to the Line A B, which is 100.

Prob. 8.

Two Right Lines being given, to find a third Line in a continual proportion to them.

Example.

Let B and C be two Lines given, and let it be required to find a third Line, which shall be in a continual proportion to them.

K 18 ——————— B

L 24 ——————— C

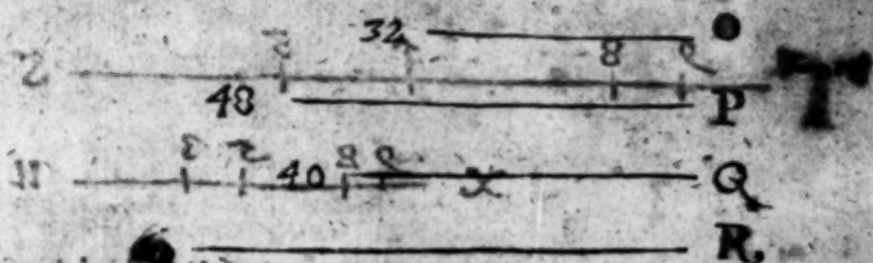
Take in your Compasses out of the Line of equal parts, the lesser Line B, and setting one foot in 24, the Term of the greater Line C; bring the Thred to the nearest distance; —Then out of the Line of equal parts take the Line C, and with this distance move one foot of the Compasses along the Line, till the other being turned about, do only touch the Thred; so shall the Compass-point rest in 32, which is the third proportional Line required.

Prob. 9.

Three Right Lines being given, to find a fourth which shall be in a discontinued proportion to them.

Example

Let the three given Lines be O P Q, *viz.* O 32 parts, P 48 parts, and Q 40 parts, and let it be required to find a fourth Line R, which shall be in proportion to them.



Take the first Line O 32, and set it in 48, the Term of the second Line P, bringing the Thred to its nearest distance:—Then take the Line Q 40, out of the Line, and with that distance move one foot of the Compasses along the Line, till the other do only touch the Thred; so shall the moveable point rest in 60, which is the Line R, and the fourth proportional Line required.

Prob.

other Lines; so shall the Line L rest in 50, and the Line K in 30; and such proportion shall the Lines K L and M have to the Line A B, which is 100.

Prob. 8.

Two Right Lines being given, to find a … *continual proportion to them*

Example.

Let B and C be two Lines given, and … red to find a third Line, which shall be … proportion to them.

Take in your Compasses out of the Line of equal parts, the lesser Line B, and setting one foot in 24, the Term of the greater Line C; bring the Thred to the nearest distance; —— Then out of the Line of equal parts take the Line C, and with this distance move one foot of the Compasses along the Line, till the other being turned about, do only touch the Thred; so shall the Compass-point rest in 32, which is the third proportional Line required.

Prob.

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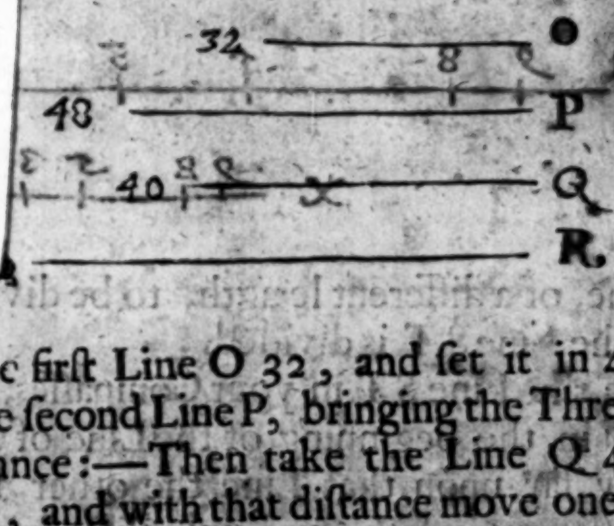


Take the first Line O 32, and set it in 48, the Term of the second Line P, bringing the Thred to its nearest distance:—Then take the Line Q 40, out of the Line, and with that distance move one foot of the Compasses along the Line, till the other do only touch the Thred; so shall the moveable point rest in 60, which is the Line R, and the fourth proportional Line required.

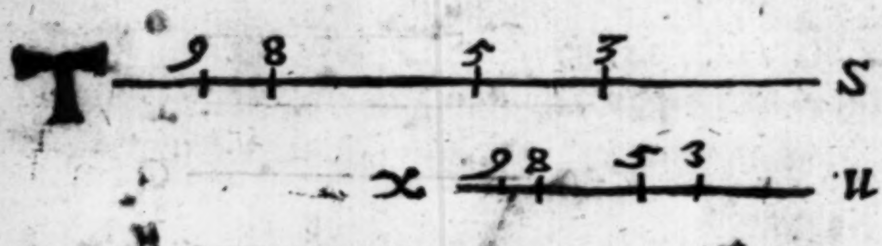
Prob.

Prob. 10.

A Right Line, which is divided into any parts, either equal or unequal, being given, how to divide a Line of another length, into the same proportional parts.

Example

Let S T be a Line given, which is unequally divided in the points 3, 5, 8 and 9, and let V X be another Line, of a different length, to be divided in such sort as the Line S T is divided.



Take the Line S T in your Compasses, and setting one foot in the beginning of the Line of equal parts; see how far upon that Line the other foot of the Compasses extendeth, and note that point; suppose it to be 85: then take the other Line V X in your Compasses, and setting one foot of that extent in the point where the other Line S T ended (*viz.* in 85) to that point, bringing the Thred to the nearest distance, and there keep it. —— Then take S 9 in the Compasses, and set one foot in the beginning of the Line, and from that point to which the other point of the Compasses reacheth, take the nearest distance to the Thred, and

that

that ſhall give the point V 9 in the other Line.—Again, take S 8, and ſet it upon the Line of equal parts, from the beginning of it, and from that point to which the Compaſs-point reacheth, take the neareſt diſtance to the Thred, ſo ſhall that extent give the diſtance V 8 upon the other Line V X; and in the ſame manner may you find the diſtance S 5, and S 3, upon the Line V X.

SECT.

SECT. IV.

Shewing the General Uses of the Lines of SQUARES and CUBES, singly, and also joyned with the Line of EQUAL PARTS; in Arithmetick, *and in* Plain *and* Solid Geometry.

I. *In* Arithmetick.

Prob. 1.

BEtween two Numbers given, to find a Mean Proportional.

This Probleme is to be performed by the joynt use of the Lines of *Equal Parts* and *Squares*.

Example.

Let the two Numbers given be 32 *&c.* 72, and let it be required to find a Mean Proportional Number between them.

Take the lesser of the given Numbers (*viz.* 32) out of the Line of equal parts, and set one foot of that distance upon the same Number 32, in the Line of

of Squares, bringing the Thred to the nearest distance; then from the Term of the other given Number 72, take the nearest distance to the Thred, which distance measured upon the Line of equal parts, shall reach from the beginning thereof, to 48, which is the Mean proportional number between 32 and 72. And from hence will follow,

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Prob. 2.

A Number being given, to find the Square Root thereof.

In finding the square Root of a Number given, you must consider, if the given number consist of an odd number of Figures, as of one, three, or five figures, the number must be taken out of the Line of Squares, between the Center and the first Figure of One:—— But if the given Number consist of an even Number of places, then the Number must be taken out of the Line of Squares, between the first figure of One, and the end of the Line: Thus, finding the square root o a number giv

Example 1.

Let it be required to find the square Root of 64.

Here the number of the places are even, (*viz.* two) wherefore, out of the Line of Squares, from the Center, take the distance to 64 (counted between the first One, and the end of the Line:) This distance applied to the Line of equal parts, shall reach from the beginning thereof to 8, so is 8 the square Root to find the squa root of 64

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of Squares, bringing the Thred to the nearest distance; then from the Term of the other given Number 72, take the nearest distance to the Thred, which distance measured upon the Line of equal parts, shall reach from the beginning thereof, to 48, which is the Mean proportional number between 32 and 72. And from hence will follow,

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Prob. 2.

A Number being given, to find the Square Root thereof.

In finding the square Root of a Number given, you must consider, if the given number consist of an odd number of Figures, as of one, three, or five figures, the number must be taken out of the Line of Squares, between the Center and the first Figure of One: —— But if the given Number consist of an even Number of places, then the Number must be taken out of the Line of Squares, between the first figure of One, and the end of the Line: Thus, finding the square root of a number given

Example 1.

Let it be required to find the square Root of 64.

Here the number of the places are even, (*viz.* two) wherefore, out of the Line of Squares, from the Center, take the distance to 64 (counted between the fitst One, and the end of the Line:) This distance applied to the Line of equal parts, shall reach from the beginning thereof to 8, so is 8 the square Root to find the square root of 64

SECT. IV.

Shewing the General Uses of the Lines of SQUARES and CUBES, singly, and also joyned with the Line of EQUAL PARTS; in Arithmetick, *and in* Plain *and* Solid Geometry.

I. *In* Arithmetick.

Prob. 1.

BEtween two Numbers given, to find
Proportional.

This Probleme is to be performed by the joyn
of the Lines of *Equal Parts* and *Squares*.

Example.

Let the two Numbers given be 32 *&c.* 72, and let it be required to find a Mean Proportional Number between them.

Take the lesser of the given Numbers (*viz.* 32) out of the Line of equal parts, and set one foot of that distance upon the same Number 32, in the Line of

of Squares, bringing the Thred to the nearest distance; then from the Term of the other given Number 72, take the nearest distance to the Thred, which distance measured upon the Line of equal parts, shall reach from the beginning thereof, to 48, which is the Mean proportional number between 32 and 72. And from hence will follow,

---

Prob. 2.

rregular
agination.

...iven, to find the Square Root thereof.

...uare Root of a Number given, you ...he given number consist of an odd ...s, as of one, three, or five figures, ...e taken out of the Line of Squares, ...r and the first Figure of One: —— ...umber consist of an even Number ...e Number must be taken out of the ...between the first figure of One, and ... Line: Thus, finding the square root of a number given

Example 1.

Let it be required to find the square Root of 64.

Here the number of the places are even, (*viz.* two) wherefore, out of the Line of Squares, from the Center, take the distance to 64 (counted between the fitst One, and the end of the Line:) This distance applied to the Line of equal parts, shall reach from the beginning thereof to 8, so is 8 the square Root to find the square root of 64

G of

of 64.——And in the same manner, 9 will be found to be the square Root of 81, *&c.*

Example 2.

Let it be required to find the square Root of 841.

Here the Number of the Places are odd (*viz.* three) wherefore out of the Line of Squares, take from the beginning thereof, to 841, (counted between the Center and the first one) this distance measured on the Line of equal parts, shall reach from the beginning thereof to 29, which is the square Root of 841. And in this manner the square Root of 725 will be 27 near, *&c.*

Thus on the contrary, if a Root be given, the Square thereof may be found; if out of the Line of equal parts, you take the Root given, and apply it to the Line of Squares, it shall there give you the Square thereof. So 6 being a Root given, if out of the Line of equal parts you take 6, that distance upon the Line of Squares shall reach to 36, which is the Square of 6.

Prob. 3.

Three Numbers being given, to find a fourth in a triplicated proportion.

This Probleme is to be performed by the joint use of the line of equal parts and *Cubes.*

Exam-

Example.

Let the given Numbers be as 55 to 88, so 125 to what Number in a triplicated proportion?

Here the two first Terms being of one kind, the two latter must be of another kind; wherefore to bring the middle Term to be of the same kind with that which is enquired, change the Term of the proportion thus;

As 55 to 125 :: so 88 to what?

The Terms being thus disposed, compare the first and second Terms in the Proportion together, and you shall find that 55 measured upon the equal parts, is longer than 125 measured upon the Cubes; wherefore the proportion must be wrought upon the Line of equal parts.——Therefore take 125 out of the Line of Cubes, and with that distance, set one foot upon 55 in the Line of equal parts, bringing the Thred to the nearest distance.——Then from 88 in the equal parts, take the nearest distance to the Thred; this distance measured upon the Line of Cubes, shall reach to 512, which is the fourth Term required; so that,

As 55 is to 88 :: So is 125 to 512 in a triplicated proportion:

Or, which is the same in effect;

As 55 is to 88 :: { So is 5 (the Cubick Root of 125) To 8 (the Cubick Root of 512) } in a simple proportion.

Prob. 4.

Having two (Lines or) Numbers given, to find two mean Proportionals.

This Probleme is to be performed by the joint uſe of the Lines of equal Parts and Cubes.

Example.

Let the two extream Numbers given be 512 and 216.

Out of the Line of equal parts take (216) one of the extream Numbers given, and ſet it upon the ſame Number counted upon the Line of Cubes, bringing the Thred to the neareſt diſtance; then from the other extream Number (512) counted alſo upon the Line of Cubes) take the neareſt diſtance to the Thred; this diſtance meaſured upon the Line of equal parts, ſhall give 288; which is one of the mean proportionals: and if you take 512 out of the equal parts, and put that in 512 in the Line of Cubes, bringing the Thred to the neareſt diſtance, and from 216, take the neareſt diſtance to the Thred; that diſtance ſhall reach upon the equal parts, to 384, which ſhall be the other mean proportional.—— And from hence will follow;

Prob.

Prob. 5.

Any Number being given, , to find the Cubick Root thereof.

In the extraction of the *Cubick Root*, it is usual to set Pricks under the first, fourth, seventh and tenth Figures from the right hand; and so many pricks as are over the number, of so many places shall the *Root* consist: So that if the number given be less than 1000, the Root shall consist but of one Figure; if less than 1000000, of two Figures; if less than 1000000000, of three Figures, *&c.*

Hence it is, that the Line of *Cubes* is first divided into 1000 parts. And if the Number given be greater than 1000, the first One must signifie 1000, the second One 10000, the third 100000, and the whole Line 1000000, & so forward, if it were necessary.

Now for the finding of the *Cubick Root* of any Number out of the Line of Cubes, take the distance from the Center of the Instrument to the number given; that distance applied to the Line of equal parts, shall there give you the *Cube Root* required.

Example 1.

Let 512 *be a number given, and let the* Cubick Root *be required.*

The number given, being less than 1000, the Root thereof can consist but of one Figure, and so the whole Line of Cubes is to be accounted but 1000 parts:

parts: Wherefore, from the Center or beginning of the Line of Cubes, take the diſtance to 512; which diſtance, applied to the Line of equal parts, ſhall reach to 8; which is the Cubick Root of 512.

Example 2.

Let 411875 *be a Number whoſe Cubick Root is required.*

Here the Number being under 1000000, the Root thereof will conſiſt but of two Figures, and the whole Line muſt be now eſtimated to be 1000000; wherefore from the beginning of the Line of Cubes, take the diſtance to 411875, which, applied to the Line of equal parts, will there fall upon 75, which is the Cubick Root of 411875.

Example 3.

Let 729000000 *be given, and the Cube Root required.*

Here the Nnmber being leſs than 1000000000, the Root will conſiſt but of three Figures; wherefore, This Number being taken from the Line of Cubes, and applied to the Line of equal parts, will give 900 for the Cube Root thereof. And accordingly,

$$\text{The Cube Root of (8)} \begin{Bmatrix} 125 \\ 6859 \\ 12649337 \end{Bmatrix} \begin{Bmatrix} \text{will be} \\ \text{found} \\ \text{to be} \end{Bmatrix} \begin{Bmatrix} 5 \\ 19 \\ 233, \textit{\&c.} \end{Bmatrix}$$

And by the converſe of this Probleme, and theſe three laſt Examples, if a Roott Cubick be given,

ven, the Number (or Cube thereof) may be found; for,

If you take the Root out of the Line of equal parts, and apply that distance to the Line of Cubes from the Center, or beginning, it shall there shew the Cube thereof.

So 7 being a Root given, the Cube thereof will be found to be 343.

II. In

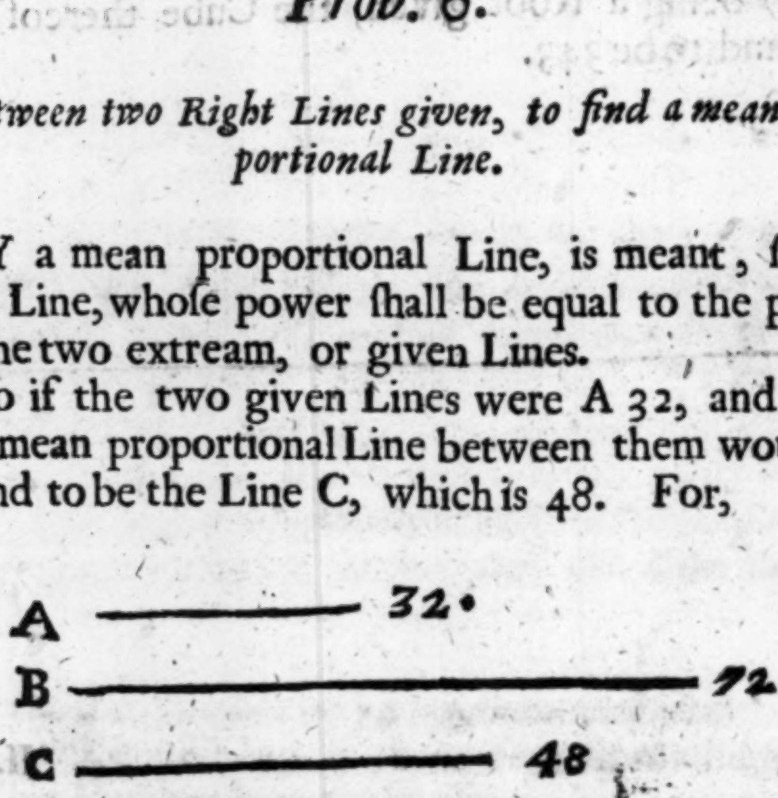
II. *In* Plain Geometry.

Prob. 6.

Between two Right Lines given, to find a mean proportional Line.

BY a mean proportional Line, is meant, ſuch a Line, whoſe power ſhall be equal to the power of the two extream, or given Lines.

So if the two given Lines were A 32, and B 72, the mean proportional Line between them would be found to be the Line C, which is 48. For,



Arithmetically, thus:

The two Lines given A 32, and B 72, being multiplied in each other, produce 2304, the Square Root whereof is 48, which is the Line C, and is equal in power to the two Lines A and B; for multiplying 48 by 48, it ſhall alſo produce 2304.

72	48
32	48
144	384
216	192
2304	2304

By the *Instrument*, thus;

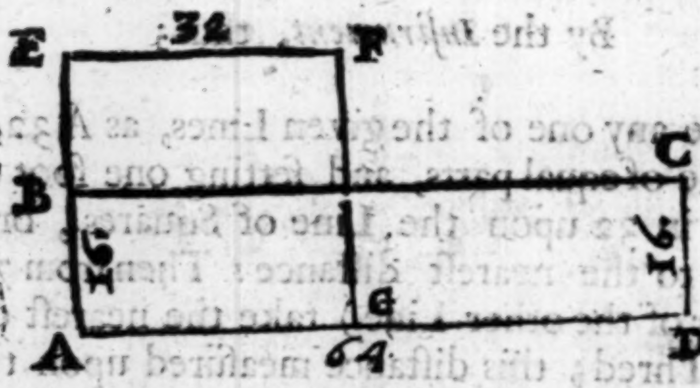
Take any one of the given Lines, as A 32, out of the Line of equal parts, and ſetting one foot of that extent in 32 upon the Line of Squares, bring the Thred to the neareſt diſtance: Then from 72 (the number of the other Line) take the neareſt diſtance to the Thred; this diſtance meaſured upon the Line of equal parts, ſhall give 48, for the *mean Proportional* required.

Again,

If the two given Lines had been 40, and 90, the mean proportional between them would be 60: And ſo of any other Numbers. And upon this Probleme of finding a mean proportional, many Corollaries of good uſe do ariſe; ſome whereof follow.

Prob. 7.

To reduce a Long Square into a Geometrical Square.



That is to make a Geometrical Square A E F G, which shall be of equal Content or *Area* with the *Parallelogram*, or Long Square, A B C D.

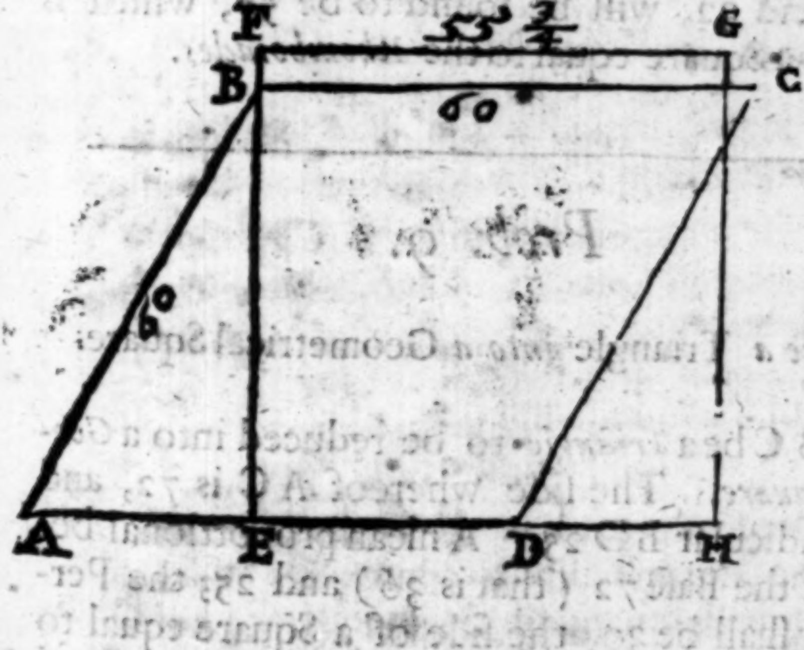
Here the two Sides of the Long Square are B C 64, and C D 16; between which two Lines (by the last *Probleme*) you shall find a mean proportionable to be 32, so that a *Geometrical Square*, whose side is 32, shall be equal in *Area* to a *Long Square*, whose sides are 64 and 16.

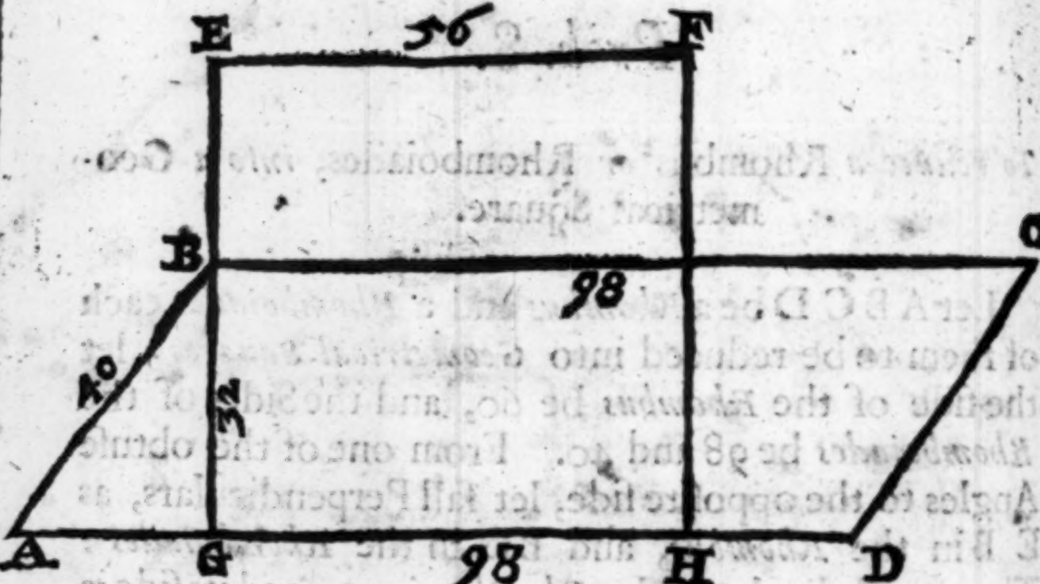
Prob.

Prob. 8.

To reduce a Rhombus *or* Rhomboiades, *into a* Geometrical Square.

Let A B C D be a *Rhombus* and a *Rhomboiades*, each of them to be reduced into *Geometrical Squares*; let the ſide of the *Rhombus* be 60, and the Sides of the *Rhomboiades* be 98 and 40. From one of the obtuſe Angles to the oppoſite ſide, let fall Perpendiculars, as E B in the *Rhombus*, and B G in the *Rhomboiades*: The perpendicular in the *Rhombus* is 52, and its ſide is 60; ſo a mean proportional between 52 and 60, ſhall be 55 and three quarters; which being made the ſide of a Square, that Square ſhall be equal to the *Rhombus*.





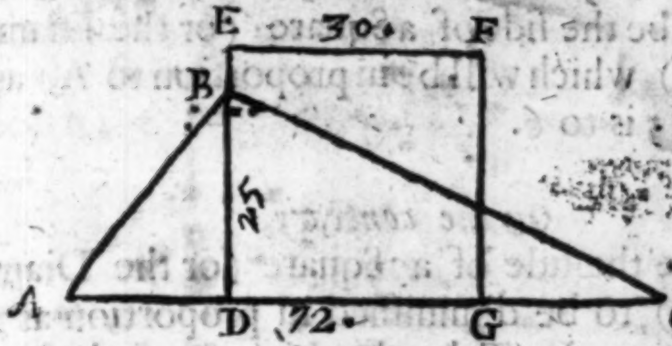
And in the *Rhomboiades* the Perpendicular is 32, and the longer side 98: A mean proportional between 98 and 32, will be found to be 56, which is the side of a Square equal to the *Rhomboiades*.

Prob. 9.

To reduce a Triangle *into a* Geometrical Square.

Let A B C be a *Triangle* to be reduced into a *Geometrical Square*. The side whereof A C is 72, and the Perpendicular B D 25. A mean proportional between half the Base 72 (that is 36) and 25, the Perpendicular shall be 30, the side of a Square equal to the Triangle.

And

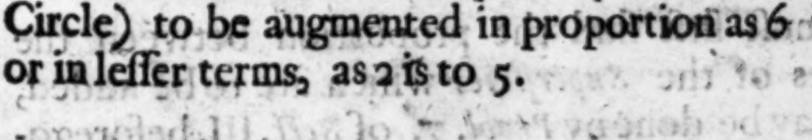


And thus may any other irregular *Poligon* be reduced into a *Square*, if first you reduce it into Triangles, and those Triangles into Squares, and add them all together, by the following *Problemes*.

Prob. 10.

To increase or diminish a Superficies, *in a given Proportion*

Let A be the Side of a Square (or the Diameter of a Circle) to be augmented in proportion as 6 is to 15, or in lesser terms, as 2 is to 5.



Take the Line A, and set one foot of the Compasses in the point 2 of the Squares, and bring the Thred to the nearest distance; then the nearest distance

ſtance between 5 and the Thred, ſhall be the Line B, which ſhall be the ſide of a Square (or the Diameter of a Circle) which will be in proportion to A, as 5 is to 2, or as 15 is to 6.

On the contrary,

If B were the ſide of a Square (or the Diameter of a Circle) to be diminiſhed in proportion as 15 is to 6, (or 5 to 2) Take the Line B, and ſet one foot in 5 of the Squares, bringing the Thred to the neareſt diſtance; the neareſt diſtance taken between 2 and the Thred, ſhall be the Line A, and ſhall be the ſide of a Square (or Diameter of a Circle) diminiſhed in proportion as 2 is to 5 (or 6 to 15.)

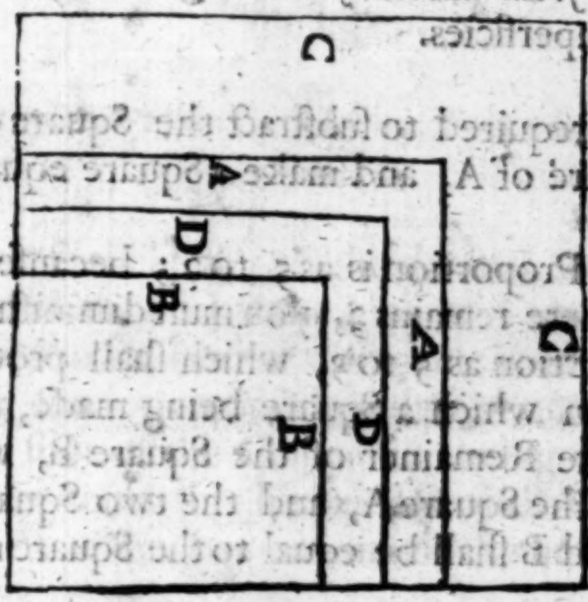
Prob. II.

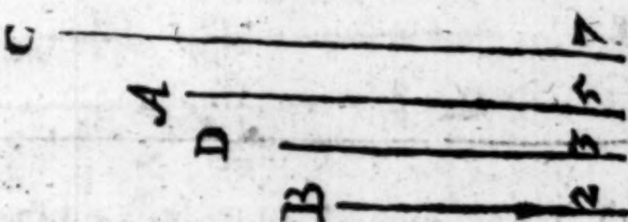
To add two Squares, Circles, or other like Superficies *together, and to give the Sum of them in a third* Superficies.

You muſt firſt find the proportion between the like ſides of the *Superficies* which are to be added, which may be done by *Probl.* 7. of *Sect.* III. beforegoing; then add the Numbers of thoſe Proportions together, and augment them by this laſt *Probleme.*

Let A and B be the Sides of two Squares (or the Diameters of two Circles) and let it be required to make a third Square, which ſhall be equal unto them. Firſt, The Proportion between the Squares of A and B, will be found to be as 5 to 2; which two being added

added together, make 7: Wherefore augment the given side A, in proportion as 5 to 7, and it produceth the side C; upon which Line a Square being made, it shall be equal to both the Squares made of A and B.



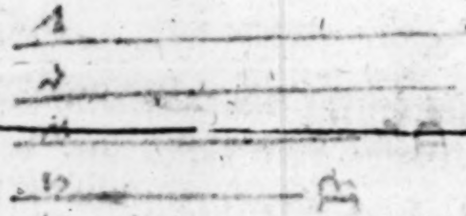


Prob. 12.

To ſubſtract two Squares, Circles, *or other like* Superficies *one from another, and to give the Remainer in a third* Superficies.

Let it be required to ſubſtract the Square of B out of the Square of A, and make a Square equal to the Remainer.

Here the Proportion is as 5 to 2; becauſe 2 taken out of 5, there remains 3, you muſt diminiſh the ſide A, in proportion as 5 to 3, which ſhall produce the ſide D, upon which a Square being made, it will be equal to the Remainer of the Square B, when it is taken from the Square A, and the two Squares made upon D and B ſhall be equal to the Square made upon A.



III. *In* Solid Geometry.

Prob. 13.

Between two like Solids, as Cubes, Spheres, *&c. to find a Proportion.*

Take one of the Sides of the greater Solid, and ſet it in 1000 at the end of the Line of Cubes, bringing the Thred to the neareſt diſtance; then take the like ſide of the other Solid, moving it along the Line till the foot of the Compaſſes, being moved about, do only touch the Thred; ſo ſhall the moveable point reſt at the proportion which the leſſer Solid hath to the greater.

M ———————————————— 1000

N ——————————— 400

Let M and N be the ſides of two like Cubes, or the Diameters of two Spheres.

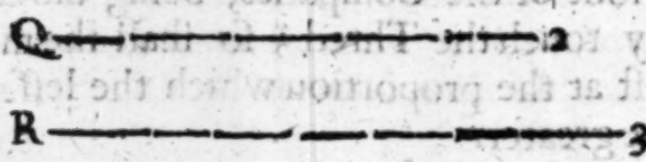
Take M the greater, and ſet it in 1000, bringing the Thred to the neareſt diſtance; then take N the leſſer, and enter it between the Line and the Thred, and you ſhall find it to reſt in 400; and as 1000 is to 400, ſo is the greater Solid to the leſſer.

Prob. 14.

A Solid being given, to augment or diminish the same in a given proportion.

Let Q be the side of a *Solid* given as *Cube, &c.* to be augmented in proportion, as 2 to 3.

Take the Line Q, and set it in the point 2, of the Line of Cubes, bringing the Thred to the nearest distance; then the nearest distance from 3 to the Thred, shall give the Line R, upon which, the like *Solid* being made, it shall be in proportion as 3 to 2.



On the contrary,

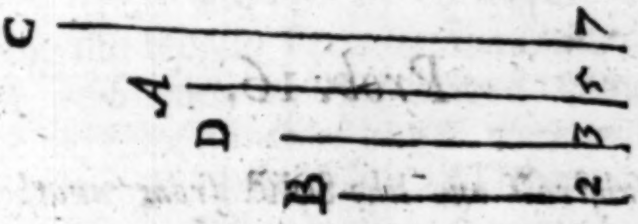
If R were the Diameter of a Sphere, to be diminished in proportion as 3 to 2;

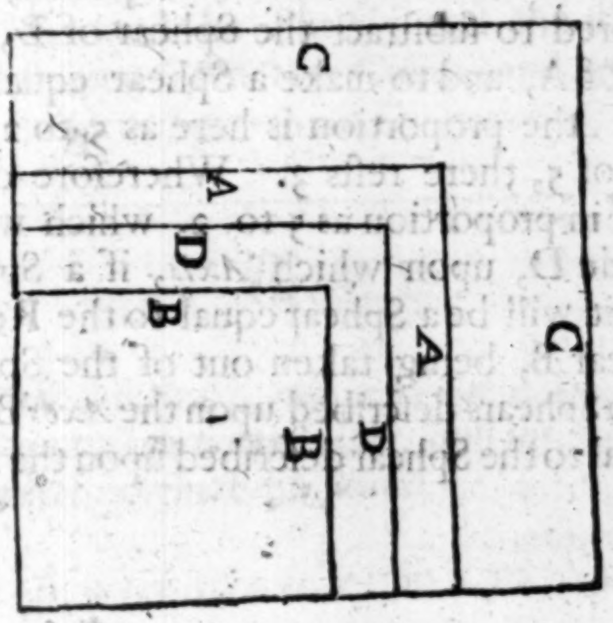
Take the Line R, and set it in the point 3, of the Cubes, bringing the Thred to the nearest distance; the distance between the point 2, and the Thred, shall be the Line Q; upon which Axis a Sphear being described, it shall be diminished in proportion, as 2 is less than three.

Prob. 15.

To add two like Solids *together.*

You must first find what proportion is between the correspondent sides of the like *Solids*, by the 12th *Probleme* beforegoing.





Thus if A and B were the ſides of two Cubes, and it were required to make a third Cube, which ſhould be equal to them both. By the 12th. *Probl.* the proportion of the ſides will be found to be as 5 to 2; and 5 and 2 added, make 7; wherefore (by the laſt *Probl.*) augment the ſide A, in proportion as 5 to 7, which will produce the Line C, upon which a Cube being made, it ſhall be equal to the two Cubes made upon A and B.

Prob. 16.

To ſubſtract one like Solid *from another.*

If A and B were the *Axes* of two Sphears, and it were required to ſubſtract the Sphear of B, out of the Sphear of A, and to make a Sphear equal to the Remainer; the proportion is here as 5 to 2, and 2 taken out of 5, there reſts 3. Wherefore diminiſh the *Axis* A, in proportion as 5 to 2, which will produce the ſide D, upon which *Axis*, if a Sphear be deſcribed, it will be a Sphear equal to the Remainer of the Sphear B, being taken out of the Sphear A, and the two Sphears deſcribed upon the *Axes* B and D, ſhall be equal to the Sphear deſcribed upon the *Axis* A.

Prob.

Prob. 17.

There is a *Bullet*, whose Diameter is 4 Inches, and it weighs 9 pound, what will another *Bullet* of the same Metal weigh, whose Diameter is 8 Inches?

As 4 inches to 9 *l.* :: So 8 in. to what?

This is to be wrought by equal parts and Cubes; and seeing the second Term is greater than the first, it must be performed by the second General Rule; wherefore, take 4 inches out of the equal parts, and set one foot in 9, in the Line of Cubes, bringing the Thred to the nearest distance; then take 8 inches out of the equal parts, and enter that distance between the Cubes and the Thred, and the Compass-point shall rest upon 72 in the Cubes, and so many pound shall a Bullet weigh whose Diameter is 8 inches.

Prob. 18.

If a Cube of Brass, whose side is 4 Inches, do weigh 9 pound, how many Inches shall the side of that Cube be which weigheth 72 pound?

As 9 *l.* is to 4 *in.* : : So is 72 to what?

The second Term is less than the first; therefore by the first general Rule; take 4 out of the Line of equal

qual parts, and ſet it in 9 in the Cubes, bringing the Thred to the neareſt diſtance; then from 72 in the Cubes, take the neareſt diſtance to the Thred, this meaſured upon the equal parts, ſhall give 8 Inches, for the ſide of the Cube which weigheth 72 pound.

Lawrence ffairclough Boar & ffountain in Lothbury 1680

SECT.

SECT. V.

The Uses of the Line of CHORDS.

THe principal Uses of the Line of *Chords* are for the Mensuration of *Arks* and *Angles*, and some few other purposes, which shall be exemplified in the following *Problemes*.

Prob. I.

The Radius *or* Semidiameter *of a* Circle *being given, to set off any Quantity of Degrees upon that* Circle.

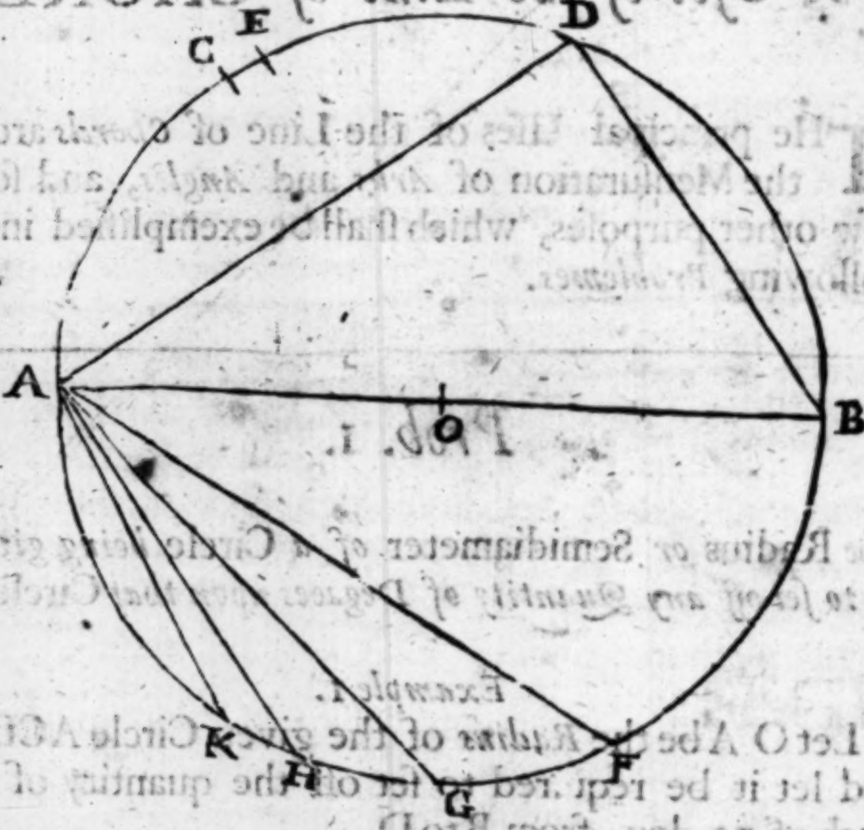
Example I.

Let O A be the *Radius* of the given Circle ACDB, and let it be required to set off the quantity of an Arch of 72 deg. from B to D.

Take in your Compasses the given *Radius* O A, and with that extent of the Compasses, set one foot in 60 deg. of the Line of *Chords*, bringing the Thred to the nearest distance; then the nearest distance taken from 72 deg. to the Thred, shall reach from B to D; so doth the Arch B D contain 72 deg. and the right Line BD is the *Chord* of 72 deg. O A being the *Radius* or *Semidiameter*.——And thus may you set off the quantity of any Arch, not exceeding 90 deg.

But

But if it be required to ſet off an Arch exceeding 90 deg. you may ſet it off at twice, by dividing the deg. given, into any two parts, and taking of them off ſeverally.



Example 2.

Let it be required to ſet off an Arch of 108 deg. from A towards D.

Having taken the *Radius* of the Circle A O in your Compaſſes, and ſet one foot in 60 deg. and brought the Thred to the neareſt diſtance; you may then from the half of 108 (*viz.* 54 deg.) take the neareſt di-

ſtance

ſtance to the Thred; ſo ſhall that diſtance reach from A to C, and from C to D; ſo a Line drawn from A to D, ſhall be the Chord, and A C D an Arch of 108 deg.

Or,

When you had taken the *Radius* of the Circle in your Compaſſes, and ſet it in 60 deg. and brought the Thred to the neareſt diſtance, you might have ſet that diſtance from A to E; then (becauſe 60 deg. wants 48 deg. of 108) take the neareſt diſtance from 48 d. to the Thred, and that ſet from E to D, ſhall give A E D for an arch of 108 deg. and the right line A D for the Chord thereof.

Prob. 2.

The Quantity of any Arch of a Circle being given, to find the Radius *or* Semidiameter *of that Circle.*

Example 1.

Let D B be an Arch of a Circle containing 72 deg. and let it be required to find the *Radius* of that Circle.

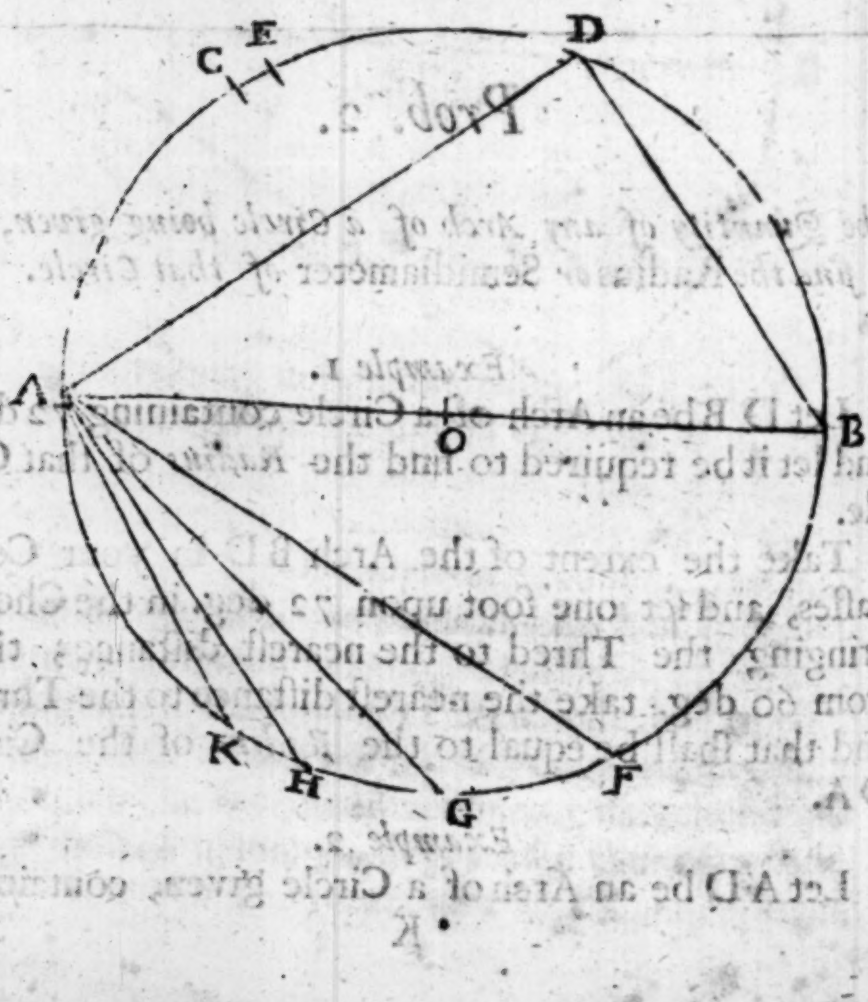
Take the extent of the Arch B D in your Compaſſes, and ſet one foot upon 72 deg. in the Chord, bringing the Thred to the neareſt diſtance; then from 60 deg. take the neareſt diſtance to the Thred, and that ſhall be equal to the *Radius* of the Circle O A.

Example 2.

Let A D be an Arch of a Circle given, containing

108 deg. and let it be required to find the *Radius* or *Semidiameter* of the Circle.

Here (because the Arch exceedeth 90 deg.) you may divide it into two equal parts in C, so shall the one half thereof (either C A or C D) contain half 108 deg. *viz.* 54 deg. wherefore, with the distance AC or C D, set one foot of the Compasses in 54 deg. of the Line of Chords, and bring the Thred to the nearest distance; then the nearest distance taken from 60 deg. to the Thred, shall give the length of O A, the *Semidiameter* of the Circle, as before.



To

To Perform the latter part of the two former Problemes by the Line of Sines.

When any Arch exceeding 90 deg. is required to be ſet off, it is beſt to uſe the Line of *Sines* inſtead of the Line of *Chords*; as in the ſecond example of the firſt *Probl.* where it was required to ſet off an Arch of 108 deg. from A to D.

By the Line of Sines, *thus:*

Take A O the *Radius* of the given Circle, and ſet one foot in 30 deg. thereof (which is half 60 deg. and bring the thred to the neareſt diſtance; then the neareſt diſtance taken from 54 deg. the (half of 108) to the Thred, ſhall give A D for the Chord, and A E D for the Arch of 108 deg.

On the contrary.

When an Arch exceeding 90 deg. is given, and the *Radius* of the Circle required, as in the latter part of the ſecond *Probl.*

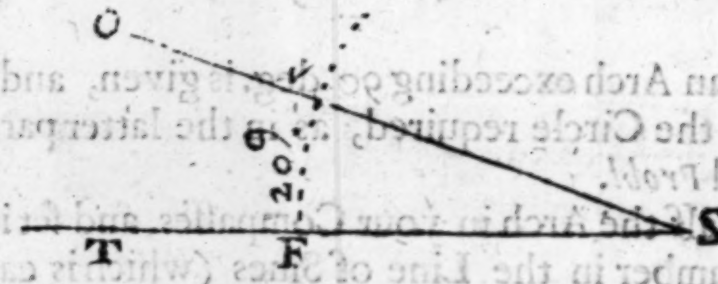
Take half the Arch in your Compaſſes, and ſet it in half its number in the Line of Sines (which is eaſily done by counting 5 deg. of the Sines to be 10, and 10 to be 20, 30 to be 60, *&c.*) and bring the Thred to the neareſt diſtance, the neareſt diſtance taken between 30 d. and the Thred, ſhall be O A the Semidiameter of the Circle.

Prob. 3.

How to find the quantity, or what number of degrees any Angle containeth.

Let O S T be an Angle, whose quantity I do require in Degrees and Minutes.

Open your Compasses to any distance (not exceeding the length of the shortest Line, and setting one foot in the angular point S, with the other describe the Arch V P; and your Compasses so resting, set one foot of that extent in 60 of the Line of Chords, bringing the Thred to the nearest distance, & keeping the Thred there, take the distance of the Arch contained between P and V, with which distance move one



foot gently along the Chords, till the other, being turned about, do only touch the Thred, then where the Compass-point resteth, that is the quantity of the Angle required; suppose in our Example 20 deg.

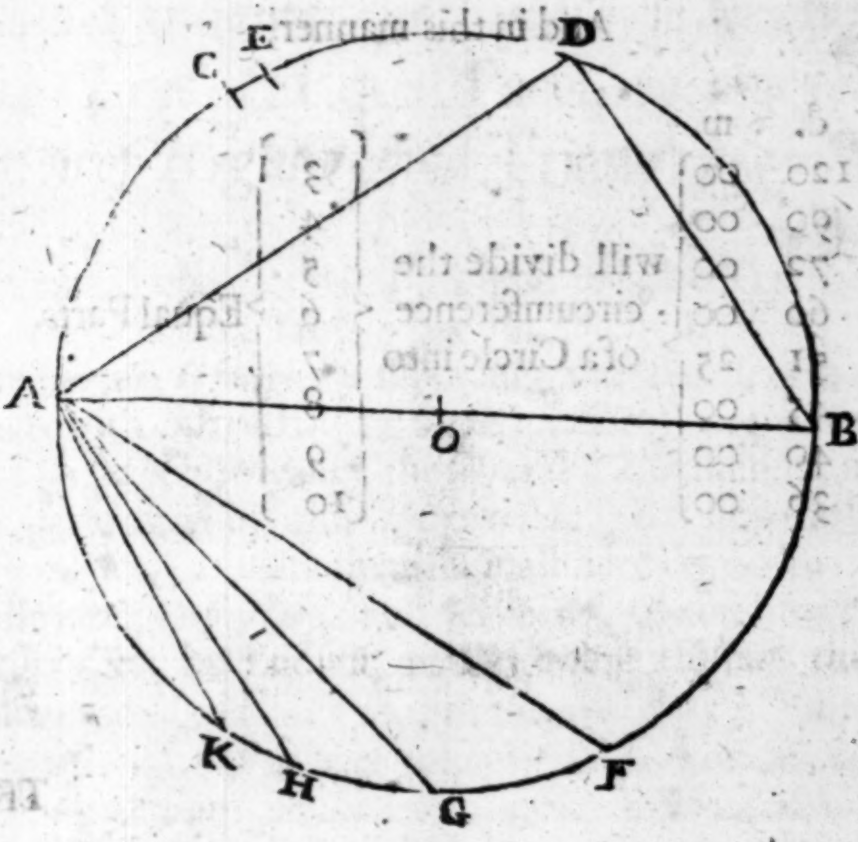
Note, that if the Angle whose quantity is required, appear to be above 90 d. you may then use the Sines instead of the Chords, as is before-directed.

Probl.

Prob. 4.

A Circle being given, how to divide the Circumference thereof into any number of equal Parts.

Let A D B F be a Circle given, and let it be required to divide the Circumference thereof into 5 equal parts.



Into

¶ Into whatsoever number of parts you intend to divide your Circumference, divide 360 by that number, so shall the *Quotient* shew the number of degrees, and parts of a degree, which being taken from your Chord, will divide the circumference of your Circle into the parts required.

Thus the Circle ADBF being to be divided into 5 equal parts, 360 being divided by 5, will give in the *Quotient* 72; so that 72 deg. taken from the Chord, will reach from A to H, and being turned 5 times about, will justly divide the circumference into 5 equal parts.

And in this manner,

d.	m.			
120	00	will divide the circumference of a Circle into	3	Equal Parts.
90	00		4	
72	00		5	
60	00		6	
51	25		7	
45	00		8	
40	00		9	
36	00		10	

TRI-

TRIGONOMETRIA, *Plain and Spherical.*

SECT. VI.

Shewing the Use of the Lines of Sines, *and* Tangents, *as they are joyned with the Line of* Equal Parts, *in the solution of Right-Lined* Triangles.

I intend not in this Section an absolute Treatise of *TRIGONOMETRIA*, or the *Doctrine of the Dimension of Triangles*; supposing the Reader to be therewith already (in some measure) acquainted; but to shew how easily the several *Cases* thereof may be performed by this *Instrument*: But for the supply of such as want them, I shall here lay down these following *Definitions* and *Theorems*, as absolutely necessary to be known, and as being assistant thereunto.

TRIGO-

TRIGONOMETRICAL Theorems.

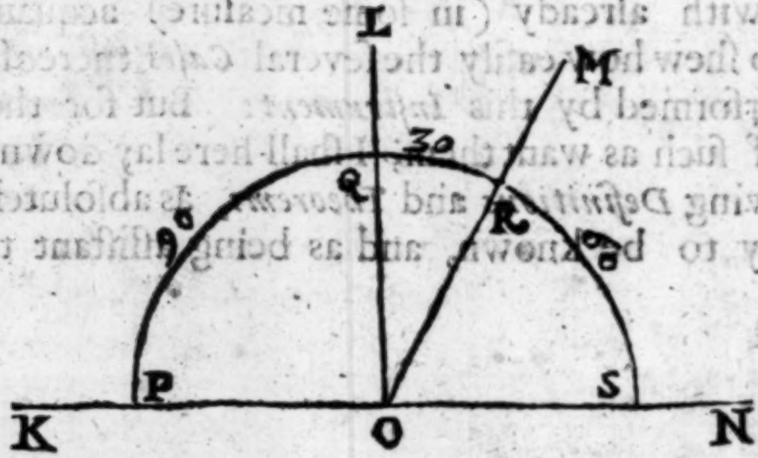
1. A *Triangle* is a Figure conſiſting of ſix parts, of 3 ſides, and as many Angles; of which ſome be called *Plain Triangles*, and ſome *Spherical*.

2. A *Plain Triangle* is that which is deſcribed upon a plain Surface, whoſe three ſides are right Lines, and is either *Right* or *Oblique* Angled; and,

3. A *Spherical Triangle* is that which is deſcribed upon a Spherical Superficies, whoſe three ſides are Arches of three great Circles, deſcribed upon the three angular points, as their Poles, and ſubtending their Angles; and of theſe ſome are *Rectangled*, others *Oblique-angled*.

4. An *Angle* (whether Plain or Spherical) is either *Right*, *Obtuſe* or *Acute*.

5. Every Angle is noted with three Letters, of which the middlemoſt Letter ſheweth the Angular point, as in this Figure; if we ſay the Angle L O K,



then

then O represents the angular point, and the two Lines K O and L O are the Lines or Sides containing the same Angle L O K.

6. A *Right Lined Right Angle* is made, whenas one Right Line, as L O, standeth upon another Right Line K N, makes the Angles on either side thereof, *viz.* the Angles K O L and L O N equal; then both those Angles are Right Angles, and the Line L O is a Perpendicular to the Line K N.

7. An *acute Angle* is less than a right Angle, as the Angle M O N is an acute Angle, it being less than the right Angle L O N.

8. An *Obtuse Angle* is greater than a right Angle, as the Angle K O M, which is greater than the right Angle K O L.

9. The quantity of an Angle is the Arch of a Circle, described upon the angular point, and in right lined Triangles never exceedeth a Semicircle, or 180 deg. So the Semicircle P Q R S, being described upon the angular point O, giveth the quantity of those three Angles contained within that Semicircle; as

P Q	is the quan-	Right		K O L.
Q R	tity of	Acute	Angle	L O M.
P R	the	Obtuse		K O M.

10. A *Degree* is the 360th. part of any Circle; so that 180 deg. is a *Semicircle*, 90 deg. a *Quadrant*, or fourth part of a Circle.

	Right		K O L		90	
So the	Acute	Angle	L O M	contains	30	deg
	Obtuse		K O M		120	

L

11.

11. The *Complement of an Angle*, less than 90 deg. is so much as that Angle wants of 90 deg. So the Angle L O M is the complement of the Angle M O N to 90 deg. for L O M being 30 deg. wants 60 deg. of 90; and M O N being 60 deg. is therefore the complement of L O M; and so they are (either of them) complements one of another to a Quadrant, or 90 deg.

12. The *Complement of an obtuse Angle* to a Semicircle or 180 deg. is so much as the said Angle wants of 180 deg. So the obtuse Angle K O M containing 120 deg. its complement is 60 deg. for 120 deg. wants 60 deg. of 180.

13. In all right Lined Triangles whatsoever, the three Angles thereof together, are equal to two right Angles, and do alwayes contain 180 deg.

14. In a right angled plain Triangle, if you have one of the acute Angles given, you have the other also given; they being complements one of another to 90 deg. as in the right angled Triangle following A B C, right angled at A; now if either of the Angles at B or C be given, the other is also known; for Angle B being 36 deg. 52 min. that taken from 90 deg. leaves 53 d. 8 m for the Angle at C. Or, if the Angle C had been given, the Angle at B had been known, by substracting 53 d. 8 m. from 90 d. for then there would have remained 36 d. 52 m.

15. In an oblique angled Triangle, if you have any two of the Angles given, the third is also known, it being the complement of the sum of the other two, to 180 deg. Thus in the oblique angled Triangle B C D, if the Angles at B and C be given, the Angle at D is known; for the Angle at B being

36 deg. 52 min. and the Angle at C 112 deg. 46 m. theſe added together, make 149 deg. 38 min. which being taken from 180 deg, leaves 30 d. 22 m. for the third Angle at D.

16. In all Triangles whatſoever, the ſides are in proportion one to the other, as are the Sines of thoſe Angles which are oppoſite to thoſe Sides. Thus in the Triangle B C D, the Sine of the Angle at B, is in proportion to the ſide C D, as the Sine of the Angle at D is in proportion to the ſide C B, and in ſuch proportion is the Sine of the Angle C, to the ſide D B.

17. In every right angled plain Triangle, that ſide which is oppoſite to the right Angle, I call the *Hypotenſe*; and the longeſt of the other two, the *Baſe*; and the ſhorter of them the *Perpendicular*. So in the Triangle A B C, the ſide C B is the *Hypotenuſe*, B A the *Baſe*, and C A the *Perpendicular*.

18. The two ſides of a Triangle which meet in the angular point, are called the containing ſides of that Angle; and the other ſide is called the ſide ſubtending, or oppoſite ſide: So in the oblique Triangle B C D, the ſides D C and C B are called the ſides containing the Angle at C, and the ſide D B is the ſubtending ſide.

19. For the abbreviation of the Proportion, by which every *Caſe* in the following Diſcourſe is to be wrought, I ſhall here explain; uſing theſe Abbreviations or Symboles:

As { S. for *Sine*, / T. for *Tangent*. / : ſo *To*. }

{ S C. for *Sine Complement*. / T C. for *Tangent Complement*. / : : for *So is*. }

Abbreviation of Proportion
Abbreviation of proportion

{ *L.* for *Latus*, or *Side*.
{ < for *Angle*.

And in this manner may an Analogy or Proportion be expressed with much brevity; thus.

That is y^t as y^e Sine of y^e Angle at A is in Proportion to y^e side B C So is y^e sine of y^e Angle at B to y^e side C A.

As *S.* < A : *L.* B C : : *S.* < B : *L.* C A.

Which is thus to be read,

As the Sine of the Angle at A is in proportion to the Side B C, So is the Sine of the Angle at B to the Side C A.

And now that I may the more methodically proceed in shewing the Uses of the several Lines upon the Instrument in the *Doctrine of Triangles*, I shall so dispose the several *Cases*, both of Right and Oblique angled plain Triangles, by beginning with such *Cases* as are resolveable

{ 1. By *Sines* } and *Equal Parts*.
{ 2. By *Tangents* }

And in *Spherical Triangles*, with such *Cases* as are resolveable

{ 1. By *Sines* alone.
{ 2. By *Sines* and *Tangents* joyntly.
{ 3. By *Versed Sines*.

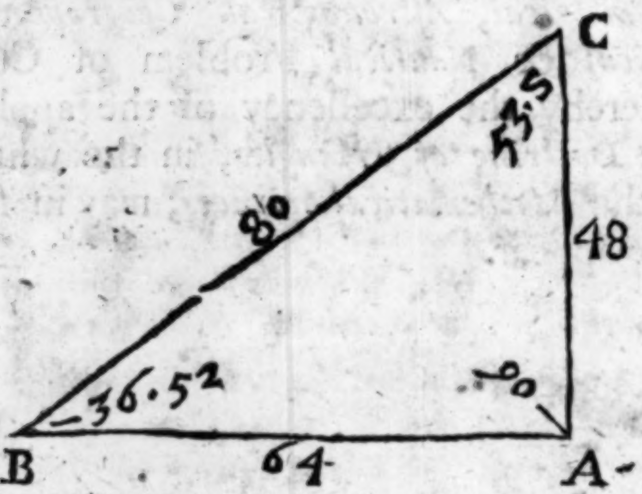
And to every *Case* I shall

1. Symbolically lay down the *Canon*, *Analogy* or *Proportion* by which that *Case* may be wrought by the *Canons* or Tables of *Sines*, &c.
2. The manner of working it upon the *Instrument*. And,
3. At the close of the resolution of each *Case*, I shall apply the same *Case* to the working of some *Geometrical*, *Astronomical*, *Geographical*, *Horological* or *Nautical* Problem or Conclusion; whereby the excellency of the application of the *Doctrine of Triangles*, in the whole course of the *Mathematical Sciences*, may in some measure appear.

Lawrence Fairclough 16..

Of Right angled plain Triangles.

THe Right angled plain Triangle, which I shall make use of in the several *Cases*, let be this following A B C, in which,



The Side	A B is the *Base*	containing	64	yards, feet, poles, leagues, or any other measure.
	B C is the *Hypotenuse*		80	
	C A is the *Perpendicular*		48	

			d.	m.
The angle	A is a *Right* Angle	containing	90	00
	B is the Angle at the *Base*		36	52
	C is the Angle at the *Perpendicular*		53	08

Now follow the several *Cases*.

I. *Cases*

I. *Cases in* Sines *and* Equal Parts.

Case I.

***The Base* B A *64, and the Angle at the Base* B *36, 52, being given, to find the Perpendicular* C A.**

Note here, that all such *Cases* as are to be performed by *Sines* and *Equal Parts*, are best to be wrought by the large Line of *Sines* on the foreside of the *Instrument*.

As *S C.* < B 53. 8m. *L.*BA 64 : : *S.* < B 36.52 : *L.* CA.

Take 64 out of the equal parts, and set that distance in 53 d. 8 m. of the Sines, bringing the Thred to the nearest distance; then from 36 d. 52 m. take the nearest distance to the Thred; this distance measured upon the equal parts, shall give 48 for the side C A.

And thus, if C A were a *Tree*, *Steeple*, or other Building, and standing at B, you would know the height thereof; the Angle at B, is your Angle observed by a *Quadrant* or other *Instrument*; the Base BA is your measured distance; by which two, the enquired *Altitude* may be found.

Case

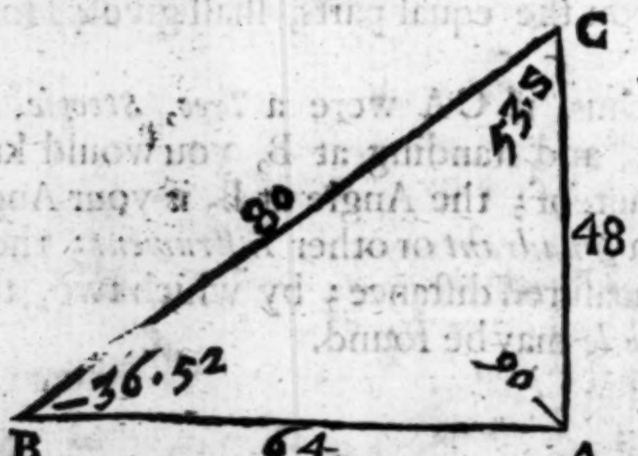
Case 2.

The Hypotenuse B C 80, *and the Base* AB 64, *being giving, to find the Angle at the Base* B.

As *S.* < A, 90 d. : *L.* BC 80 :: *L.* AB 64 : *S C.* < B.

Take 80 out of the equal parts, and set one foot thereof in 90 deg. of the Sines, bringing the Thred to the nearest distance; then take 64 out of the equal parts, and enter that distance between the Sines and the Thred, so shall the Compass-point rest at 53 deg. 8 m. which is the complement of the Angle at B.

And thus, if B were a *Sea-Port*, and A and C two Ships, which had set sail from thence, the Ship A had sailed from the Port South 64 Leagues; and the other had sailed more Westward 80 Leagues; and it had been required to know upon what point of the Compass the Ship C had sailed; the Angle B being 36 deg. 52 m. shews that it had sailed S.W. by S. 3 d. and 7 m. Westerly.



Case 3.

Case 3.

The Hypotenuſe B C 80, *and* Baſe A B 64, *being given, to find the* Perpendicular.

As $L.BC\ 80 : s\angle A\ 90\,d :: L.BA : s\angle C$.

Take 80 out of the equal parts, and ſetting one foot in 90 of the Sines, bringing the Thred to the neareſt diſtance; then take 64 from the equal parts, and enter it between the Sines and the Thred, ſo ſhall the Compaſs-point reſt upon 53 deg. 8 m. the Angle at C.

A Ship at A, ſees an Iſland at C, which bears from him directly Eaſt; and a Port at B, which bears from him directly North, and is diſtant 64 Leagues; and this Iſland at C, is diſtant from the Port at B, 80 Leag. Now to know how the Iſland C, bears from the Ship A, and the Port B: The Iſland bears from the Ship A directly Weſt, then the Angle C being 53 d. 8 m. ſhews, that it bears N.W. ½ a point, and 2 d. 31 m. Northerly.

Caſe 4.

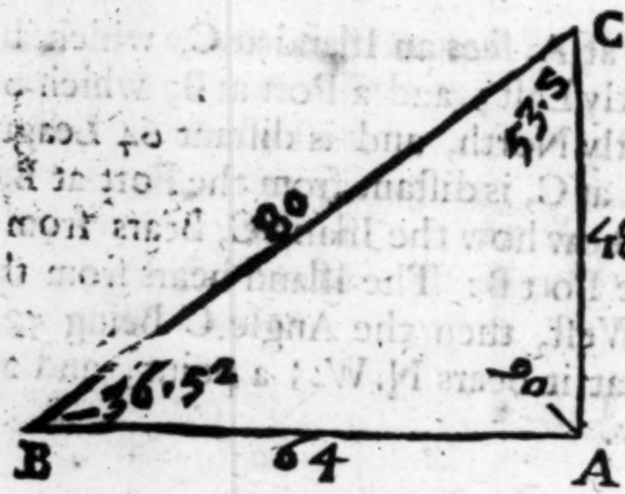
The Baſe B A 64, *and the* Angle *at the* Perpendicular C 53 d. 8 m. *being given, to find the* Hypotenuſe.

As $s\angle C$, 53 d. 8 m. : $L.BA\ 64 :: s\angle A\ 90\,d : L.BC$.

Take 64 out of the equal parts, and ſet one foot of that diſtance in 53 deg. 8 m. of the Sines, bringing the

the Thred to the nearest Distance; then from the Sine of 90, take the nearest distance to the Thred; this measured upon the equal parts, shall give 80 for the *Hypotenuse* BC.

Now, if C A were the Wall of a *Fort* or *Castle* besieged, about which there were a *Moat* of 64 foot broad, as BA, and you would know what length a Scaling Ladder must be, to reach from C, the top of the Wall, to B, the Brow of the Trench; by *Quadrant* or other *Instrument* observing the Angle at C, to be 53 d. 8 m. By this *Case*, the length of the side (or Ladder) will be found to be 80 foot.



Case 5.

The Hypotenuse CB 80, *and* Angle *at the* Base B 36 d. 52 m. *to find the* Base BA.

As *L*.BC 80 : *s* $<$A 90 : : *s C.* $<$B 53 8 : *L*. B A.

Take 80 from the equal parts, and set it in the Sine of

of 90, bringing the Thred to the neareſt diſtance; then from 53 d. 8 m. take the neareſt diſtance to the Thred; which meaſured upon the equal parts, ſhall give 64 for the Baſe B A.

If C were the Top of a Hill, to the top whereof, from B, the foot thereof, were 80 paces, and the Aſcent obſerved by Inſtrument, were 36 deg. 52 m. and it were required to find the Horizontal or Level Line of that Hill; by the reſolving of this Caſe it will be found to be 64 paces.

II. *Caſes in* Tangents *and* equal Parts.

Caſe 6.

The Baſe A B 64, *and the* Perpendicular C A 48, *being given, to find the* Angles C *or* B.

Theſe Caſes which are to be performed by *Tangents* and *Equal Parts*, are beſt to be wrought upon the *Line of Tangents*, and the *leſſer line* of *Equal Parts* on the backſide of the Inſtrument.

As, *L.* A B 64 : *T.* < A 45 d : : *L.* CA 48 : *T* < B.

Out of the leſſer Line of Equal Parts, take 64, and ſet that diſtance in 45 d. of the Line of *Tangents*, bringing the Thred to the neareſt diſtance; then out of the ſame equal parts take 48, and enter this diſtance

stance between the *Tangent* Line and the Thred; so shall the Compass-point rest upon 36 d. 52 m. which is the quantity of the Angle at B.

By this *Case* may the Suns Altitude be obtained; for suppose C A to be a Staffe, or the like Gnomon of 48 inches long, set up perpendicularly on a plain Level; and the Sun shining, should cast the Shadow hereof to B; which measured, and found to be 64 inches: Then by resolving this *Case*, the Suns Altitude at that time will be found to be 36 d. 52 m.

Case 7.

The Base A B 64, *and the* Perpendicular C A 48, *being given, to find the* Hypotenuse C B.

You must first, by the last *Case* before-going, find one of the Angles B or C, and then by the 4th. *Case* you may find the *Hypotenuse*.

And these are all the Cases in right angled plain Triangles; and so we will proceed to the *Cases*.

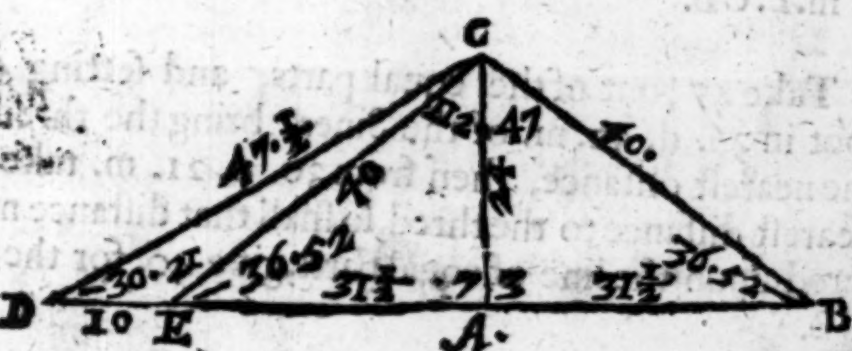
Of

Of Oblique Angled Plain Triangles.

THe *Oblique Angled Plain Triangle* which I shall make use of in the following Cases, shall be this CDB, in which,

The Side	D B the *Base*	contains	73	yards, feet
	D C the *Longer*		475	Perches,
	C B the *Shorter*		40	Leagues,
	the *Perpendicular* C A		24	or any other measure.
	the *Segments* of the *Base* D A		$41\frac{1}{2}$	
	the *Segments* of the *Base* A B		$31\frac{1}{2}$	

			d.	m.
The Angle	C is an *obtuse* Angle	containing	112	46
	D is an *acute* Angle		30	22
	B is an *acute* Angle		36	52



I. *Cases in Sines and Equal Parts.*

Case 1.

Two Angles D 30 d. 21 m. *and* 1 C 117 d. 47 m. *with the Side* D C 47 $\frac{1}{2}$ *comprehended between them, being given, to find the third Angle* B, *and any of the other two Sides CB or DB.*

First, For the finding of the third Angle at B,

The Angle	D is	30. d.	21. m.	
	C is	112.	47.	
Their Sum		143	08	which taken from 180 d
Leaves		36	52	for the Angle at B.

Secondly, For any of the sides, as 1. for C B

As S<B 36 d. 52 : *L*. D C 47 $\frac{1}{2}$: : S<D 30. d. 21. m. *L*. CB.

Take 47 $\frac{1}{2}$ out of the equal parts, and setting one foot in 36. d. 52. m. of the Sines, bring the thred to the nearest distance, then from 30. d. 21. m. take the nearest distance to the thred, so shall that distance measured upon the line of equal parts, give 40. for the side CB.

2. For

2. For the ſide D B.

As S < B 36 d. 52 m: L. D C 47 ½ :: S < A 112 d. 47 m. (or its complement to a ſemicircle 67 d. 14 m.) L. D B.

Take 47 ½ out of the equal parts, and ſetting one foot of the Compaſſes in 36 d. 52 m. of the Sines, bring the thred to the neareſt diſtance; then from 67 d. 14 m. of the Sines, take the neareſt diſtance to the thred, ſo ſhall that diſtance reach upon the equal parts to 73, which is the length of the ſide D B.

By this Caſe may be found the diſtance of places upon the Land, or of Ships upon the Sea: For, ſuppoſing B to be ſome Fort, Caſtle, or other place upon the Land remote from you, or ſome Ships upon the Sea which you cannot approach, yet you would know how far it is diſtant from the place of your ſtanding at D.——Having a *Theodolite* (or other Surveying Inſtrument) place it at D, and direct the Sights to B, then ſeeing ſome other convenient place upon the Land, where alſo you may place your Inſtrument (as at CD) direct your Sighr thither, and obſerve what angle C makes with B, which let be 30. deg. 21. m. which is the angle at D, and meaſuring the diſtance D C you find it 47 Pole and oo, half; Again placing your Inſtrument at C, obſerve what angle is contained betweem D and B, which let be 112 deg. 46 m. and this is the angle at C. So now having the angles D and C, with the ſide between them, you may (as in this caſe is directed) find the diſtance of the *Tower*, or *Ship* at B, to be diſtant from D 73 Pole, and from C 40 Pole.

Caſe 2.

Case 2.

Two sides, as DC 47 ; and DB 73. *and an angle opposite to one of them, namely, the Obtuse angle at* C, 112 d. 47 m. (*or as its complement*) 67 d. 14.) *to find the other side* C B, *and the two other angles* D *and* B.

As S C< C 67 d. 14 m : *L.* DB 73:
S<D 30 d. 21 m. : *L.* CB

Take 73 out of the equal parts, and set one foot of that distance in 67 d. 14 m. of the Sines, bringing the the thred to the Nearest distance, th en from 30 d. 21. m. take the nearest distance to the thrid, so shall that distance give upon the equal parts 40, for the side CB.

And thus the three sides and the angle C being known, it is easie to find either of the other Angles B or D, For:

1. As L. DB: S< C : : L. C B: S< D
And : : L DC : S< B

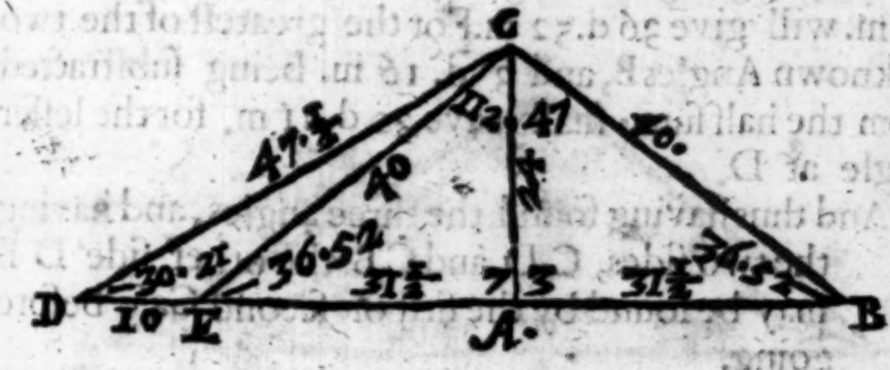
And t his Case may be applyed to diverse the like Geometrical conclusions as the last Case was :

II. Cases

II. *Cases in* Tangents *and* Equal Parts.

Case 3.

Two sides C D 47 ½, *and* C B 40 *with the angle at* C 112 *deg.* 47 (*included between them*) *being given to find the other two angles* D *and* B, *and the third side* DB



First, Take the sum and difference of the two given sides DC and CB, — Take half the Sum of the two unknown Angles D and B, thus

The side D C ---	47 ½	The sum of the two unknown Angles is ---	deg. 67	m. 13
The side CB ---	40			
Their Sum	87 ½	Their half sum	33.	36
Their difference	7 ½			

Then the proportion is

As the ſum of the ſides, DC and CB 87 ½
Is the Tangent of half the Sum of the unknown Angles 33 d. 36 m.
So is their difference 7½
To the Tangent of 3 d. 16 m.

Take 33 d. 36 m. out of the Line of Tangents, and ſetting one foot thereof in 87 ½ of the Equal Parts, bring the Thred to the Neareſt Diſtance, then from 7 ½ of the Equal Parts, take the Neareſt Diſtance to the Thred, this diſtance entered between the Tangent Line and the Thred ſhall reſt upon 3 deg. 16 m. which 3 deg. 16 m. being added to the half ſum 33 d. 36 m. will give 36 d. 52 m. For the greateſt of the two unknown Angles B, and 3 d. 16 m. being ſubſtracted from the half ſum, ſhall leave 30 d. 21 m. for the leſſer angle at D.

And thus having found the three angles, and having the two ſides, C D and C B the other ſide D B may be found by the firſt or ſecond Caſe before going.

This caſe may alſo be applyed to the taking of diſtances; for ſtanding at C, and knowing the diſtance from C to B and from C to D, and alſo finding by Inſtrument what angle is made between D and B, the diſtance D B by this Caſe will be fonnd to be 73 Rod or Pole.

Case 4.

The Three sides D B 73 D C 47 ½ and C B 40, being given to find any of the Angles.

First having the greater side D B—73
The two lesser { D C —— 47 ½
Sides ——— -- { C B —— 40

Their Sum 87 ½

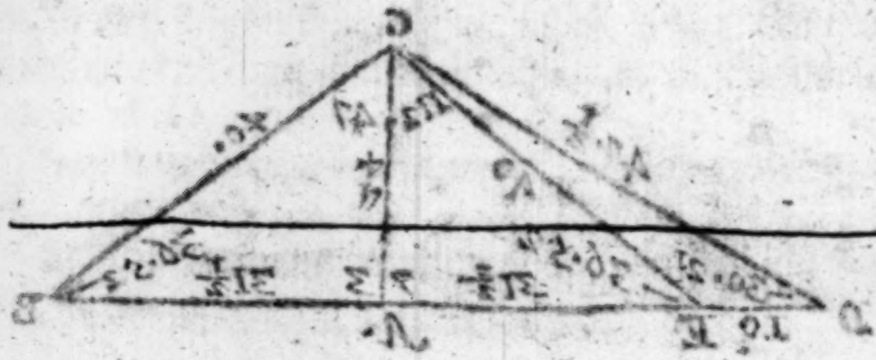
Their difference 7 ½

Then
As *L.* D B 73 *L.* D C and CB 87 ½:
:: differ of *L.* CD & CB 7 ½: DE 10

Take the greater side DB 33, out of the Line of Equal parts, and set it in the term of the Sum of the two lesser sides, *viz.* in 87 ½, bringing the Thred to the

the nearest distance; then from the difference of the two lesser sides, *viz.* 7 $\frac{1}{2}$ take the nearest distance to the Thred, and that measured upon the Equal parts shall give 10.

This 10 is D E a part of the greatest side, which being substracted from the whole side D B 73. leaves 63, and in the middle of this 63 will the Perpendicular CA fall, reducing the Oblique Triangle CD B into two Rectangled Triangles, namely, into the Triangles C A B and C A D, both right angled at A, in either of which you have two sides given besides the right angle; and so any of the other parts may be found by the 6th and 7th Cases of Right angled Plain Triangles before going. And thus I conclude with the doctrine of Plain Triangles.



SECT. VII.

Shewing the Use of the Lines of Sines, Tangents *and* Versed Sines *in the solution of* Spherical Triangles.

I. Of Right Angled Spherical Triangles.

The Right angled Spherical Triangles which I shall make use of, shall be these following.

THe first whereof DEF is composed of three Arches of great Circles of the Sphere, *viz.* upon which is counted the Suns present declination.

1. The Perpendicular D F is an Arch of the Meridian, upon which is counted the Suns distance from the Equinoctial.

2. The Hypotenuse E D is an Arch of the Ecliptick.

3. The Base F D is an Arch of the Æquator, on which is counted the Suns right Ascension.

4. The Angle at E being the intersection of the Ecliptick and *Meridian* is the Angle of the Suns *Position*.

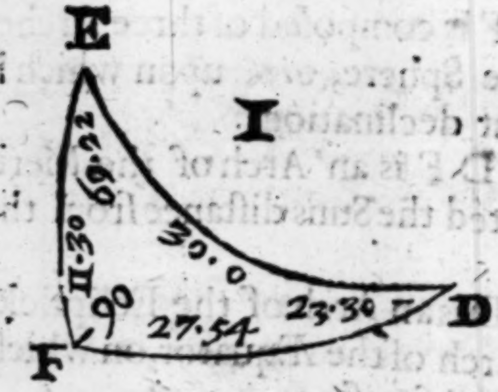
5. The

5. The Angle at D, being the interſection of the *Ecliptick* and the *Æquator*, is the Angle of the Suns greateſt *declination*.

6. The Angle F is the Right Angle, made by the interſection of the *Meridian* and the *Æquator*.

	d.	m.
The *Perpendicular* EF, is the *Suns declination*	11	30
The *Hypotenuſe* E D is the Suns *diſtance* from *Aries* or *Libra*	30	00
The *Baſe* F D, is the Suns *Right Aſcenſion*, or that diſtance of time that the Sun *Riſes* or *Sets* from 6.	27.	54
The Angle E is the Angle of the Suns *Poſition*	69.	22
The Angle D, is the angle of the Suns greateſt *declen*.	23.	30

The Angle F is a right Angle,



The

The ſecond Triangle is A B C, compoſed alſo of three Arches of great Circles of the Sphere, *viz.*

	Containing in this our Example	d. m.
1. The *Perpendicular* CA an Arch of the *Meridian*, upon which is counted the Latitude of the place.		51.32
2. The *Baſe* B A, an Arch of the *Horizon*, upon which is counted the *Amplitude* of the Suns *Riſing* and *Setting*, from the *North*.		56.40
3. The *Hypotenuſe*, C B, an Arch of another *Meridian*, upon which is counted the complement of the Suns *declination*.		7000
4. The *Angle at the Perpendicular* C, which is the hour from midnight.		62.45
5. The *Angle at the Baſe* B being the Complement of the Suns *Poſition*.		56.23
6. The right Angle at A		90. 0

Having given you a brief view of the Triangles, and what every ſide and Angle in each of them repreſents, I will now proceed to the ſeveral Caſes; and

I Caſes

I. *Cases in* Sines *alone*.

Case 1. *Triangle* 1.

The Hypotenuse, E D, and Angle at the Base D, being to find the Perpendicular E F

All these Cases in *Sines* alone are best to be wrought upon the large line of *Sines*.

As S< F 90 d. SED 30 d. : : S< D 23 d. 30 m. SEF

Out of the Line of Sines take 30 d. and set one foot of that extent in 90 d. bringing the Thred to the Nearest Distance ; then from 23 d. 30 m. take the Nearest Distance to the Thred ; which measured upon the Sines shall give 11 d. 30 m. for the perpendicular E F.

By this Case, the Suns greatest declination, G his next Equinoctial point being given, may be found the Suns present declination, *viz.* 11 d. 30 m.

Case 2. *Triangle* 1.

The Base F D, and Perpendicular E F being given, to find the Hypotenuse E D.

As < F. S 90: SCEF 78 d 30 m : : SCFC 62 d. 6 m: SCED

Take

Take 78 d. 30 m. out the Line of Sines, then ſetting one foot of that extent in 90 d. bringing the Thred to the Neareſt Diſtance; then from 62 d. 6 m. tak the Neareſt Diſtance to the Thred, which diſtance upon the Line of Sines will give 60 d. for the comeplement of E D.

And by this Caſe, if the Suns right Aſcenſion and his Declination had been given, the Suns diſtance from the next Equinoctial point *Aries* had been found 30 d.

Caſe 3. Triangle 1.

The Baſe F D, and the Angle at the Baſe D being given, to find the Angle at the Perpendicular E.

As s < F 90 d : s c A C 62 d. 6 m :
: : s < D 23 d. 30 m : s c < E.

Out of the Line of Sines take 62 d. 6 m. and ſet that diſtance in 90 d. bringing the Thred to the Neareſt Diſtance; then from 23 d. 30 m. take the Neareſt Diſtance to the Thred, and that ſhall reach upon the Line of Sines to 20 d. 32 m. the complement of the Angle at E.

By this Caſe, if the Suns right Aſcenſion, and his greateſt declination had been given, the Angle of the Suns poſition might be found to be 69 d. 28 m.

Case 4. Triangle 1.

The Perpendicular E F, and the Angle at the Base D being given, to find the Hypotenuse E D.

As s< 23 d. 30 m : s E F. 11 d. 30 m: s< F 90 d : s ED.

Take out of the Line of Sines 11 d. 30 m. and set one foot of that distance in 23 d. 30 m. bringing the Thred to the Nearest Distance. Then from 90 d. take the Nearest Distance to the Thred, this distance measured upon the Sines shall reach to 36 d. which is the Hypotenuse E D.

Thus if the Suns greatest declination and his present declination be known, his distance from the next Æquinoctial point might be found by this Case to be 30 d.

Case 5. Triangle 2.

The Perpendicular A C and Angle at the Base B being given, to find the Angle at the Perpendicular C.

As s c CA 38d. 30 m. s c< B 33d. 37 : : s< A 90 d: s< C.

Out of the Line of Sines, take 33 d. 37 m. and setting one foot of that extent in 38 d. 30 m. bring the Thred to the Nearest Distance, then from 90 d. take the Nearest Distance to the Thred, this distance measured on the Sines shall give 62 d. 45 m. for the quantity of the Angle at C.

And thus if the Latitude of the place, and the Angle of the Suns position at the time of his rising, or setting,

ting; had been given, the hour from midnight might be found, as here 62 d. 45 m. which in time is 4 hours and 11 m. which shews the time to be 49 m. past 7 of the Clock at night, or 11 m. past 4 in the morning.

Case 6. Triangle 2.

The Angle at the Base B, *and the Angle at the Perpendicular C being given, to find the Base B A.*

As s< B 56 d. 23 m. sc< C 27 d. 15 m :: s A 90 d: sc BA

Take 27 d. 15 m. out of the Sines, and set that distance to 56 d. 23 m. on the same Line, bringing the Thred to the Nearest Distance; then from 90 d. take the Nearest distance to the Thred; this distance shall reach on the Line of Sines to 56 d. 40 m. the side B A.

And thus, if the Angle of the Suns Position at the time of his Rising, and the hour from midnight, had been given, the Amplitude of the Suns Rising might be found by this Case to be 56 d. 40 m. from the North, or 33 d. 20 m. from the East.

Case 7. Triangle 2.

The Base B A and Hypotenuse C B being given to find the Angle at the Perpendicular C A.

As s B C 70 d : s A 90 d. :: s B A 56 d. 40 m. : s < C.

Take 70 d. out of the Sines, and setting one foot in 90 d. bring the Thred to the Nearest Distance. Then out of the Line of Sines, take 56 d. 40 m. and entring this distance between the Line of Sines and the Thred, the Compass point shall rest upon 62 d. 45 m. which is the quantity of the Angle at O.

And so if the Suns Amplitude at his rising or setting, with his declination had been given, the hour from midnight might have been found to be 62 d. 45 m. or 4 hours and 11 m. from midnight.

Case 8. Triangle 2.

The Base B A, and Hypotenuse CB being given, to find the perpendicular C A.

As s c BC 33 d. 20 m: s A 90 d :: s c CB 20 d: s c C A

Out of the Sines take 33 d. 20 m. and setting one foot in the Sine of 90 d. bring the Thred to the nearest distance. Then taking 20 d. out of the same line, enter that distance between the Line of Sines and the Thred, so shall the Compass point rest upon 38 d. 30 m. for the Perpendicular C A.

So if the Suns Amplitude at his rising had been observed to be 33 d. 20 m. and his declination 20 d. the Latitude of the place had been found to be 51 d. 30 m. the perpendicular C A.

II. Cases in Sines and Tangents together.

Case 9. Triangle 1.

The Hypotenuse E D, and angle at the Base D, being given, to find the angle at the Perpendicular E.

As s∠F 90 d: t∠D 23 d 30 m: : s c ED 60 d: t c∠E

Take 23 d. 30 m. out of the Line of Tangents, and setting one foot in the Sine of 90 d. bring the Thred to the Nearest Distance. Then from 60 d. of the Sines, take the nearest distance to the thred, so shall that distance reach to 20 d. 38 m. whose complement, 69 d. 22 m. is the quantity of the Angle at E.

So that if the Suns distance from the next Equinoctial point *Aries* or *Libra* had been given, together with the Suns greatest declination, the Angle of the Suns position might be found to be 69 deg. 22 m.

Case 10. Triangle 1.

The Hypotenuse E D, and the angle at the Base D being given, to find the Base F. D.

As s∠F 90 d: t E D 30 d: : s c∠D 66 d. 30 m. t FD

Out

Out of the Line of Tangents take 30 d. and ſetting one foot in the Sine of 90 d. bring the Thred to the Neareſt Diſtance; then from 66 d. 30 m. of the Sines take the Neareſt Diſtance to the Thred, ſo ſhall that diſtance meaſured upon the Tangents give 27 d. 54 m. for the ſide FD.

And thus, if the Suns Diſtance from the next Equinoctial point, and his greateſt declination had been given, the Suns Right Aſcenſion might be found to be 27 d. 54 m. which is the diſtance that the Sun riſes or or ſets before or after ſix of the Clock, which in time is 1 hour and 51 m. ſo that the Sun riſeth 1. h. 51 m. before 6 in the morning, and ſets as much after 6 at night, And thus may the length of the day and night be known as is ſhewed in the ſecond part of this Book and the 8th Aſtronomical Problem.

Caſe 11.

The Baſe F D, and the Angle at the Baſe D, being given to find the Perpendicular E F.

As s F 90 d : t∠D 23 d. 30 m :: s F D 27 d. 54 m : t EF.

Take 23 d. 30 m. out of the Line of Tangents, and ſet that diſtance in the Sine of 90 d. bringing the Thred to the Neareſt Diſtance. Then from 27 d. 54 m. of the Sines, take the Neareſt Diſtance to the Thred, and this ſhall give upon the Tangents 11 d. 30 m. for the Perpendicular E F.

So if the Suns greateſt declination and his Right Aſcenſion had been given, his declination would be found (by this Caſe) to be 11 d. 30 m.

Caſe

Case 12. Triangle 1.

The Base F D, and the Perpendicular E F being given to find the Angle at the Base.

As s F D 27 d. 54 m : t E F 11 d. 30 m : : R : t< D.

Take 11 d. 30 m, out of the Line of Tangents, and setting that distance in the Sine of 27 d. 54 m. bring the Thred to the Nearest distance; then from the Sine of 90 d. take the Nearest Distance to the Thred: this distance measured upon the Line of Tangents shall reach to 23 d. 30 m. the quantity of the Angle at D.

Thus if the Suns Right Ascension, and his present declination were given, the Suns greatest declination might be found by this Case to be 23 d. 30 m.

Case 13. Triangle 2.

The Base A B and the Angle at the Base B being given to find the Hypotenuse C B.

As sc<B 33 d. 37 m: s<A 90 d : : t BA 56 d. 40 m : t CB

This is the Canon or Proportion by which this Case is to be resolved; but in regard that the Tangents go no further than 66 d. 26 m. and in this Triangle there will be occasion sometimes to make use of a Tangent of 70 d. or more, the proportion, to bring the Case to Instrumental work; the terms of Tangents must be converted into their complements, and those of Sines transposed: thus;

As

As s<A90d: sc<B 33 d.37m : : tc BA 33d.20m: tc CB

Wherefore take 33 d. 20 m. out of the Line of Tangents, and set that distance in the Sine of 90 d. bringing the thred to the nearest distance. Then from 33 d. 37 m. of the Sines take the nearest distance to the thred; this measured upon the Line of Tangents shall give 20 d. the complement whereof 70 d. is the quantity of the Hypotenuse C B.

And thus, if the Suns Amplitude, and his Angle of position at the time of his rising, were given; the Suns declination might be found (by this Case) to be 20 d.

Case 13. Triangle 2.

The Perpendicular CB, and the Angle at the Base B being given, to find the Base B A.

As t<B 56 d.23 m: s<A 90 d : : t CA 51 d.30 m: sBA

Take 90 d. out of the Line of Sines, and set one foot of that distance in the Tangent of 56 d. 23 m. bringing the thred to the nearest distance, then from 51 d. 30 m. take the nearest distance to the thred, and that shall reach to 56 d. 40 m. upon the Sines, which is the quantity of the side B A.

In this manner, if the angle of the Suns position at the time of his rising, and the Latitude of the place were given, the Suns amplitude from the North part of

of the Meridian might be found (by this Case) to be 56 d. 40 m. or from the East or West 33 d. 20 m.

Case 15. Triangle 2.

The Base BA, and the Hypotenuse CB, being given, to find the Angle at the Base D.

As s<A 90 d: tc BA 33 d. 20 m: : tc CB 20 d: s c B.

Take 33 d. 20 m. out of the Line of Tangents, and set that in the Sine of 90 d. bringing the Thred to the Nearest Distance; then out of the Tangent Line take 20 d. and enter it between the Line of Sines and the the Thred, so shall the Compass-point rest upon the Line of Sines in 33 d. 37 m. the complement of the Angle B, which is 56 d. 23 m.

And thus if the Suns Amplitude and declination had been given, the Suns Angle of Position might be found (by this Case) to be 56 d. 23 m.

Case 16. Triangle 2.

The Angle at the Base B, and the Angle at the Perpendicular C being given, to find the Hypotenuse CB.

As t<B 56 d. 23 m: s<A 90 d: : tc<C 27 d. 15: sc BC

Take 90 d. out of the Line of Sines, and set one foot of that distance in the Tangent of 56 d. 23 m. bringing the Thred to the Nearest Distance; then from the Tangent of 27 d. 15 m. take the Nearest Distance to the Thred, which measured upon the Line

As s< A 90 d: s< B 33 d. 37 m : : tc BA 33 d. 20 m: tc CB

Wherefore take 33 d. 20 m. out of the Line of Tangents, and set that distance in the Sine of 90 d. bringing the thred to the nearest distance. Then from 33 d. 37 m. of the Sines take the nearest distance to the thred; this measured upon the Line of Tangents shall give 20 d. the complement whereof 70 d. is the quantity of the Hypotenuse CB.

And thus, if the Suns Amplitude, and his Angle of position at the time of his rising, were given; the Suns declination might be found (by this Case) to be 20 d.

Case 13. Triangle 2.

The Perpen dicular CB, and the Angle at the Base B being given, to find the Base B A.

As t< B 56 d. 23 m: s< A 90 d : : t C A 51 d. 30 m: s BA

Take 90 d. out of the Line of Sines, and set one foot of that distance in the Tangent of 56 d. 23 m. bringing the thred to the nearest distance, then from 51 d. 30 m. take the nearest distance to the thred, and that shall reach to 56 d. 40 m. upon the Sines, which is the quantity of the side B A.

In this manner, if the angle of the Suns position at the time of his rising, and the Latitude of the place were given, the Suns amplitude from the North part of

of the Meridian might be found (by this Case) to be 56 d. 40 m. or from the East or West 33 d. 20 m.

Case 15. Triangle 2.

The Base BA, and the Hypotenuse CB, being given, to find the Angle at the Base D.

As s< A 90 d: tc BA 33 d. 20 m: : tc CB 20 d: s c B.

Take 33 d. 20 m. out of the Line of Tangents, and set that in the Sine of 90 d. bringing the Thred to the Nearest Distance; then out of the Tangent Line take 20 d. and enter it between the Line of Sines and the the Thred, so shall the Compass-point rest upon the Line of Sines in 33 d. 37 m. the complement of the Angle B, which is 56 d. 23 m.

And thus if the Suns Amplitude and declination had been given, the Suns Angle of Position might be found (by this Case) to be 56 d. 23 m.

Case 16. Triangle 2.

The Angle at the Base B, and the Angle at the Perpendicnlar C being given, to find the Hypotenuse CB.

As t< B 56 d. 23 m: s< A 90 d: : tc< C 27 d. 15: sc BC

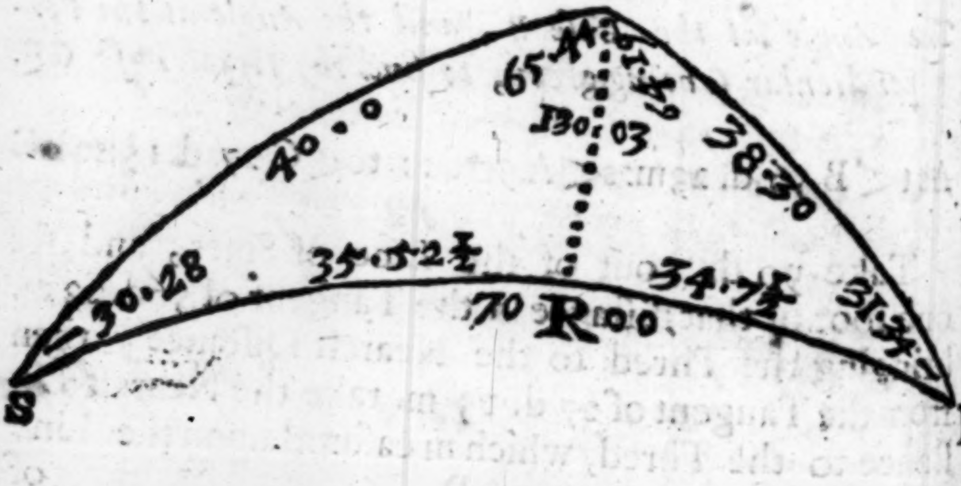
Take 90 d. out of the Line of Sines, and set one foot of that distance in the Tangent of 56 d. 23 m. bringing the Thred to the Nearest Distance; then from the Tangent of 27 d. 15 m. take the Nearest Distance to the Thred, which measured upon the Line

of Sines shall give 20 d. the complement whereof 70 d. is the side C B.

And thus, if the hour from Midnight, and the Angle of the Suns position at his rising or setting had been given; his declination might be found by this Case to be 20 d.

II. *Of* Oblique *Angled Spherical Triangles.*

The Oblique Angled Triangle which I shall make use of, shall be this followin gZ P S, consisting of the Arches of three Meridians; two of them intersecting each other in Z, the *Zenith* of the place, other two in P the *Pole* of the World, and also two of them in S the place of the *Sun* at the time of the question.



The

The Parts of the Oblique Angled Triangle are these:

			d. m.
The Side	*ZP* is the complement of the *Latitude* of the place	And contains in our Example	38.30
	ZS is the complement of the Suns *Altitude*		40.00
	SP is the complement of the Suns *declination*		70.00
The Angle	*Z* is the *Azimuth* from the North part of the Meridian		130.03
	P is the hour from noon		31.34
	S is the Angle of the *Suns Position*		30.28

In the ſolution of this, and of every oblique *Spherical Triangle*, there are 12. Caſes, and 60. varieties; of which 12. Caſes, *Five* of them are reſolvable by *Sines* alone, *Four* by *Sines* and *Tangents* together, and the three laſt (and moſt difficult) by *Verſed Sines*.

In the reſolving of the firſt nine Caſes I ſhall make the diſtinction of Sides, as of Baſe, Perpendicular, &c. but call them all Sides, without other diſtinction. And being thus far prepared, I come now to the ſolution of the ſeveral Caſes. And

of Sines shall give 20 d. the complement whereof 70 d. is the side C B.

And thus, if the hour from Midnight, and the Angle of the Suns position at his rising or setting had been given; his declination might be found by this Case to be 20 d.

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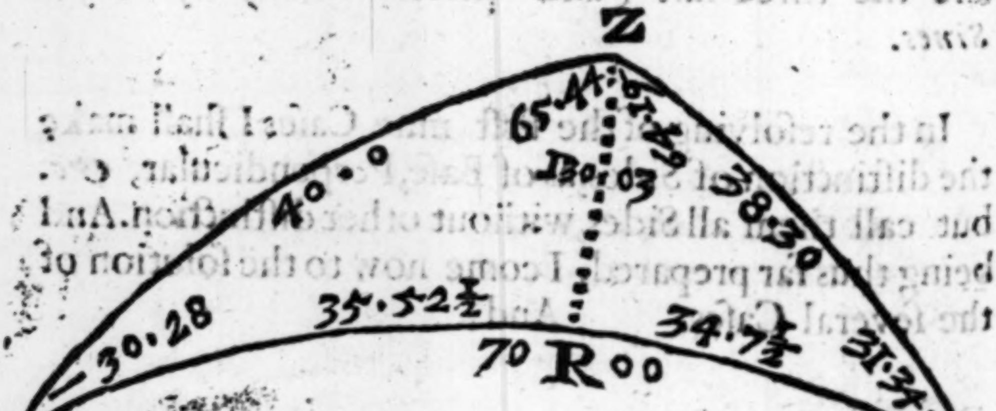
I. Cases in Sines alone.

Case I.

Two sides Z S and Z P, with the Angle at S opposite to Z P, to find the angle at P.

As s. Z P 38 d. 30 m; s<S 30 d. 28 m :: s ZS 40 d: s<P.

Take 30 d. 28 m. out of the Line of Sines, and set one foot of that distance in the Sine of 38 d. 30 m. briuging the Thred to the Nearest Distance; then from 40 d. take the Nearest Distance to the Thred; this measured upon the Sines shall give 31 d. 34 m. or the Angle at P.



By

By this Case, If the Latitude of a place, the Altitude of the Sun, and the Angle of the Suns Position were given, the hour of the day might be found, as here the Angle P, 31 d. 34 m. which in time is 2 hours, and 6 m. so that it is 54 m. past 9 in the forenoon, or 6 m. after 2 in the afternoon.

Case 2.

Two angles S and P, with the side Z S opposite to P, to find the side Z P.

As s< P 31 d. 34 m: s ZS 40 d :: s< S 30 d. 28 m: s ZP

Out of the Line of Sines take 31 d. 34 m. and set that in the Sine of 40 d. bringing the Thred to the Nearest Distance; Then take 30 d. 28 m. out of the Sines, and enter this distance between the Sines, and the Thred, so shall the compass point rest upon 38 d. 30 m. the quantity of the side Z P.

So that if the Suns Altitude, his Angle of position, and the time from midnight had been given, the Latitude might be found by this Case.

Case 3.

Two sides Z S and Z P, with the angle P adjacent to the unknown side, to find the side P S.

To resolve this Case, you must first reduce the Oblique Triangle into two right angled Triangles by letting fall the Perpendicular Z R, then in the Triangle ZPR you have given ZP and the Angle at P by which

you

you may find R P (by the 10th Case of right angled ſpherical Triangles) to be 34 d. 7½ m. Then for the other ſegment of the Baſe S R, ſay,

As s c PZ 51 d. 30 m: s c PR 55 d. 53 m :: sc ZS 50 d: sc SR

Wherefore take 51 d. 30 m. out of the Sines, and ſet that diſtance in 55 d. 53 m. bringing the Thred to the neareſt diſtance; then take 50 d. out of the Sines, and enter that diſtance between the Sines and the Thred, ſo ſhall the compaſs point reſt upon 54 d. 8½ m. the complement whereof 35 d. 52½ m. is the ſegment of the Baſe S R, which added to P R 34 d. 7½ m. giveth 70 d. for the ſide S P.

So that if the Latitude, and Suns Altitude, and the hour were given; the Suns declination, or diſtance from the Pole, might be found to be 70 d.

Caſe 4.

Two Angles Z and P, with the ſide between them Z P, given to find the Angle S.

The Triangle being reduced into 2. Right Angled Triangles, as before, you muſt by the 9th Caſe of Right Angled Spherical Triangles, find the quantity of the Angle R Z P, which will be 64 d. 19. m. which taken from 130 d. 3 m. there will remain the Angle S Z R 65 d. 44 m.

As s < P Z R 65 d. 44 m : < S Z R 64 d. 19 m. :: s c < P 58 d. 26 m. s c < S.

Take

Take 64 d. 19 m. out of the Sines, and set it in 65 d 44.m bringing the Thred to the Nearest Distance; then take the nearest distance from 58 d. 26 m. to the Thred and that distance upon the Sines shall give 58 d. 26 m. whose complement 3 d. 34 m. is the Angle S.

Thus, if the Hour, the Azimuth, and the Latitude, were given, the Angle of the Suns position might be found by this Case.

Case 5.

Two Angles S and P, with the side Z P (adjoyning to the unknown Angle Z) to find the angle at Z.

. You must first find the Angle R Z P, (by the 9th before going) as in the last Case, which will be 64 d. 19 m. Then find the other part of the Angle S Z R in this manner.

As sc< P 58 d. 26 m : s c< S 59 d. 32 m.
:: s< P Z R 64 d. 19 m: s< S Z R,

Take 58 d. 26 m out of the Line of Sines, and set it in 59 d. 32 m. of the same Line, bringing the Thred to the Nearest Distance; then take 64 d. 19 m. out of the Sines, and enter that distance between the Sines and the Thred, so shall the compass point rest upon 65 d. 45 m. which is the Angle S Z R and this added to the Angle P Z R 64 d. 19 m. makes 130 d. 3 m. for the whole Angle at Z.

And

And thus if the Latitude, the Angle of the Suns Position, and the hour were given, the Suns Azimuth might be found by this Case.

II. Cases in Sines *and* Tangents *together.*

Case 6.

Two sides Z S, *and* Z P, *with the Angle* P, *to find the Angle* Z *included between the two given sides.*

You must first find the Angle ZPR, as in the two last Cases, then

As t ZS 40d: sc∠PZR 25d.41m: t ZP 38d.30m: cs∠SZR

Take 25 d. 41 m. out of the Line of Sines, and set one foot of the Compasses in the Tangent of 40 d. bringing the Thred to the Nearest Distance; then from the Tangent of 38 d. 30 m. take the Nearest Distance to the Thred, that distance measured upon the Sines, shall reach to 24 d. 16 m. whose Complement 65 d. 44 m. is the quantity of the Angle S Z P, and that added to 64 d. 19 m. the Angle R ZP makes 310 d. 3. m. the whole Angle S Z P.

And thus, if S and P were two places, and lying in

in the Latitude of 51 d. 30 m. and the other of them in 50 d. of Latitude, and the bearing of those places were 81 d. 34 m. (which is within 2 d. 41 m. of 3. points of the Compaſs) the difference of Longitude of thoſe two places would be found to be 130 d. 3 m. which in time is 8. h. 40 m.

Caſe 7.

Two Angles Z and P, and the ſide comprehended between them Z P, given, to find the ſides Z S and S P.

Firſt find the Angles R Z P, and S Z R, as in the former Caſes, and then,

As s c < S Z R 24 d. 16 m : t P Z 38 d. 30 m.
:: s c < P Z R 25 d. 31 m : t Z S

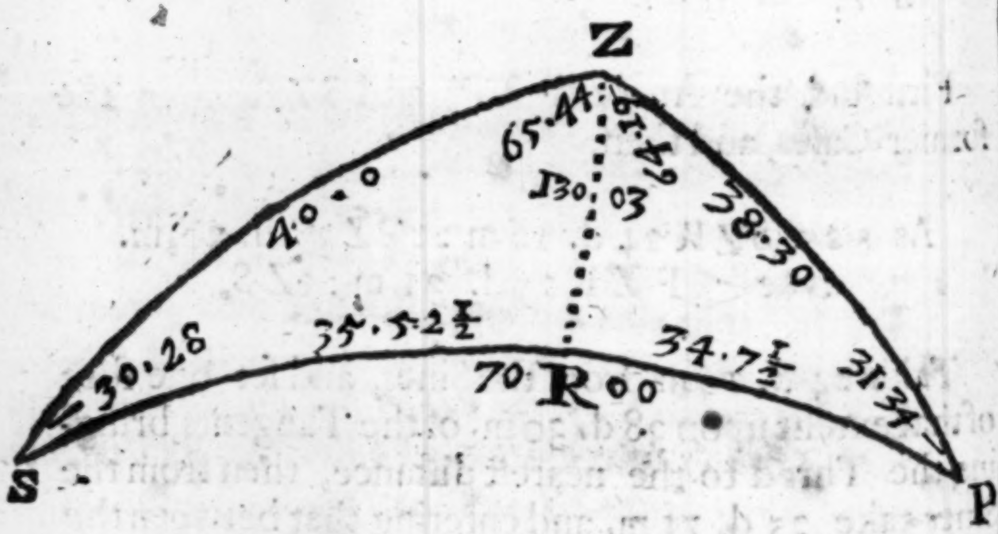
Take 24 d. 16 m. from the Sines, and ſet one foot of that extent upon 38 d. 30 m. of the Tangents, bringing the Thred to the neareſt diſtance, then from the Sines take 25 d. 71 m. and entering that between the Tangent Line and the Thred, the Compaſs point ſhall reſt upon 40 d. the quantity of the ſide Z S.

And thus, if the Hour, Azimuth, and Latitude were known, the Suns Altitude at that time might be attained by this Caſe.

Case 8.

Two Angles S and P, and the side Z P adjoyning unto the unknown Angle, to find the side S P, contained between the two given Angles S and P.

You must first (by the 10th Case of Right Angled Spherical Triangles) find the segment of the Base RP, which will be 34 d. $7\frac{1}{2}$ m : Then the proportion will be,



As t< S 30 d 28 m : s PR 34 d. $7\frac{1}{2}$ m :: t< P 81 d. 34 m : s SR

Take the Side of 34 d. $7\frac{1}{2}$ out of the Sines, and set that distance to the Tangent of 30 d. 28 m bringing the Thred to the Nearest Distance; then from the Tangent of 31 d. 34 m. take the Nearest Distance to the Thred; & this measured upon the Line of Sines, shall reach to 35 d. $52\frac{1}{2}$ m the Segment of the side SR;

which

which added to the Segment R P 34 d. 7½ m. makes 70 d for the whole ſide S P.

And ſo, if the Latitude, the Hour, and the Angle of the Suns Poſition were given, the Suns declination might be obtained.

Caſe 9.

Two Sides Z P and Z S, with the Angle P inclnded between them being given, to find the Angle at S.

You muſt firſt find the Segment P R, as in the laſt Caſe, and then the proportion will be

As s SR 35 d. 52½ m : t t<P 31 d. 34 m : : s PR 34 d. 7½ m : t<S

Here the Sine of 35 d. 52½ m. and the Tangent of 31 d. 34 m. are ſo near of one length (though in reallity, the Tangent is the longer of the two) that in Inſtrmmental practice it will be hard to determine upon which Line to work there being not above $\frac{5}{100}$ parts difference between them: twill therefore be beſt to find the length of the Perpendicular ZR alſo, and then the Angle S may eaſily may be found by the 12th Caſe of angled Triangles.

III. Cases in Versed Sines.

These three following Cases (the most useful, and the most difficult to be performed either Arithmetically or Instrumentally) are most easily and expeditiously performed by the Line of Versed Sines; and in the resolving of them you are to

Note: That the side opposite to the enquired Angle; when the 3 Sides are given, is now called the Base, and the other two sides, the Leggs, or sides of the Triangle —— And when two sides and an Angle included is given, then the side opposite to the Angle given is called the Base, and the other two the Sides.

Case 10.

Two sides Z P and Z S, and the Angle P contained between them being given, to findd the Base ZP.

First, You must finde the sum and difference of the two given Leggs or Sides of the Triangle, thus

	d:	m.
The Side or Legg Z P————	38.	30
The Side S P—————————	70.	00
Their Sum	108.	30
Their difference	31	30

Up-

Upon the Line of Versed Sines, take the distance between 108 d. 30 m. (the sum) and 31 d. 30 m. (the difference) and setting one foot of the Compasses in 108 d. (the end of the Versed Scale) bring the Thred to the Nearest Distance; then from 31 d. 34 m. (the quantity of the given Angle at P) take the Nearest Distance to the Thred; this distance upon the Versed Scale, will reach from 31 d. 30 m. (the difference) to 40 d. which is the quantity of the side Z S.

And (by this Case) if the Latitude of the Place, the Suns declination, and the hour, were given, the Suns Altitude at that hour might be found.

Case 11.

TTe three Sides Z P, Z S, and S P, being given to find the Angle at Z.

In this Case, the Angle required is the Vertical Angle, and the side opposite to it is the Base; wherefore,

fore, you must find the Sum and Difference of the two Sides, thus,

	d.	m.
The Side S Z	40.	00
The Side Z P	38.	30
Their Sum	78.	30
Their difference	1.	30

Upon the Line of Versed Sines take the distance between 78 d. 30 m. the Sum, and 1 d. 30 m. the difference of the two Sides, and setting one foot of this distance in 180 d. bring the Thred to the Nearest Distance; then from the Line of Versed Sines take the distance from the difference 1 d. 30 m. to 70 d. the Base, and enter this distance between the Versed Scale and the Thred, so shall the Compass point rest upon 130 d. 3 m. which is the quantity of the Vertical Angle at Z.

And thus, If the Latitude, the Suns Altitude, and his declination had been known, his Azimuth from the North part of the Meridian might be found.

Case 12.

Three Angles Z, S, and P, being given to find the Side ZS.

Instead of the greatest Angle next to the Side enquired, *viz.* 130 d. 30 m. if you take its Complement to 180 d. the three Angles of the Triangle will be turned into Sides, and the Sides into Angles, and the resolving of the Triangle will be

the

the ſame as in the laſt Caſe, and the three ſides of this new Triangle will be 49 d. 57 m. 31 d. 34 m. and 30 d. 28 m:

And thus have you the whole doctrine both of Plain Spherical Triangles made applicable to Inſtrumental performance; theſe 12 Caſes of Right-lined and 28 of Spherical being all the Caſes that are uſual: infinite varieties might be deduced from them, as in my 5th *Geometrical Exerciſe* I have made to appear, but my intent in this place being not to make a Treatiſe of Triangles, but to ſhew the uſes of the Lines on the Inſtrument I ſhall here conclude this Section, with this intimation, that what proportion ſoever you find in any Book, either in Sines, Tangents, or equal parts, joyntly or ſinglyt, he ſame may be wrought upon theſe Lines, by obſerving the two general Rules for the manner of working, delivered in the ſecond Section of this Book.

One other uſe of the Line of Verſed Sines.

By this Line of Verſed Sines all proportions that are in Sines alone, and the Radius or Sine of 90 deg. in the firſt place of the proportion, may be wrought without the motion of the Thred, thus: Find the ſum and difference of the ſecond and third terms of the proportion, and take the diſtance between them out of the Line of Verſed Sines, apply this diſtance to the middle of the Verſed Line, ſo as that the ſame number of degrees may be above 90, as is below, ſo

ſhall

ſhall the number of degrees counted from 90 either above or below be the fourth proportional Sine required.

Example, As in the 3d Caſe of Right Angled Spherical Triangles, this is the proportion

As s 90 : s 62 d. 6 m. : : s 23 d. 30 m. s 20 d. 32 m.

The ſum and difference of the ſecond and third terms are 85 d. 36 m. the ſum, and 38 d. 36 m. the difference; the diſtance between theſe two numbers being taken out of the Scale of Verſed Sines, and applied on either ſide of 90 d. equally ſhall reach on either ſide of 90 d. to 20 d. 32 m, if you count the ſame from 90 d. Or when you have taken the diſtance between the ſum and difference of your two terms out of your Line of Verſed Sines, if you apply that ſame diſtance to the larger Line of Sines, it ſhall reach from the beginning thereof to 20 d. 32 m. And ſo by this Artifice may the firſt, ſecond, third Caſes of Spherical Triangles, and divers other proportians in Sines alone be performed without the motion of the Thred.

PRO-

PROJECTION

Of the SPHERE, *in Plano.*

SECT. VIII.

Shewing some farther Uses of the Lines of Sines Tangents *and* Secants, *in Projecting of the Sphere or Globe in Plano.*

IT was for this reason principally, that the several Lines of *Sines*, *Tangents* and *Secants*, together with the Scale of *half Tangents*, *Equal parts* and *Chords*, are made all to one and the same *Radius* or *Semidiameter*, and Mr. *Gunter* in his Second Book of the Sector, Chapter 2. hath there shewed how to project the Sphere several wayes, *Viz.* twice upon the Plain of the *Meridian*; once upon the *Tropick* of *Capricorn*; and once upon the plain of the *Horizon*; laying down some uses of either of those Projections; And in this last Edition of Mr. *Gunters* Works, Printed in *Anno* 1672. at the conclusion of the forementioned second Chapter, I have added (amongst other additions of mine, through the whole Work) the manner how

 to

to project the Sphere (according to the *Stereographical* or *Circular* Projection) upon any *Oblique* Circle also; All which Rules there delivered, for these several Projections of Mr *Gunters*, and that other of mine, may all be applied to, and performed by these Lines thus disposed to one Radius, with wonderful Ease and Expedition; and therefore I shall leave the applying those Rules there delivered to the ingenious Students practice. And moreover, all the Rules by me delivered concerning Projection, both upon *Direct* and *Oblique* Circles of the Sphere, in my *Geometrical Exercises*, and in my Treatise of *Dialling* (both lately published) all those Rules may be brought and applied to this Instrument also: and so I shall not meddle with them at all in this place, but shew how the Sphere may be projected *in Plano*, sutable to the resolving such Problems as are of frequent use in *Astronomy*, *Dialling*, *Geography*: and (though I suppose my Reader already acquainted with some few Geometrical Elements, yet) because there is one Problem, which is not usually found in every Book of *Practical Geometry*, that comes often in use in the work of *Projection*, I shall therefore here insert it; it being the 8th Prop of my first *Geometrical Exercise*.

Proposition.

Two Points within any Circle being given, how to describe the Arch of another great Circle which shall pass through those two points, and also divide the circumference of the given Circle into two equal parts.

Let

Let the two points given be E and F, through either of which (as E) draw the right line D E, ſo as to paſs through the Centre at K; then draw the right Line AC at right Angles to BD, ſo ſhall the Circle be divided into four equal parts, by the Lines AC and BD. Again, draw the Line E A, and upon the point A erect the Perpendicular A G, cutting the Line BD (extended) in G, and ſo have you three Points E, F and G, through which, if you deſcribe a Circle (whoſe Centre will be at H) it will paſs through the two given points E and F, and alſo divide the circumference of the given Circle in two equal parts, in the points L and M.

I. *Upon the Plain of the* Meridian, *to project the Sphere in Plano, ſutable to the reſolution of divers* A-SRONOMICAL *Problems.*

Let the Fundamental or Primitive Circle ZH NO, repreſent the Meridian.

H O the Horizon.

Z N the prime vertical, or Azimuth of Eaſt or Weſt.

E Q the Equinoctial.

P M the Axis of the World, or hour of ſix.

D G K a Parallel of the Suns Declination being 20 d Northward.

Z S N an Azimuth paſſing through S the place of the Sun at the time of the queſtion.

ZCN an Azimuth passing through the place of the Sun G at 6 a clock.

ASFB a Parallel of the Suns Altitude being 40 d. high.

PXM, a Meridian or Hour Circle, cutting the Horizon at X the place of the Suns Rising.

E G F a parallel of the Suns Altitude at Six of the Cl ock.

GF the Suns Altitude when he is due East or West.

P S M A Meridian or hour Circle passing through S the place of the Sun at the time of the Question.

♋ and ♑ the Ecliptick.

Z is the Zenith and Pole of the Horizon H O, and also of all parallels of Altitude.

N the Nadir.

P the North Pole of the World : The Pole of the Equinoctial A Q, and also of the Tropicks and other parallels of declination.

S the place of the Sun at the time of the Question.

X the point in the Horizon where the Sun rises and sets.

Y	is the Pole of	The Meridian M F P
T	is the Pole of	The Meridian P S M
V	is the Pole of	The Meridian P X M
W	is the Pole of	The Azimuth Z S N
I		The Meridian Z G N

Thus for the declaration of those Circles; now for the describing of them.

First, With 60 d. of the Line of Chords, upon the Centre C, describe the Circle ZHNO representing the Meridian, and cross it at right Angles in the Centre C, with the Lines Z N the prime Vertical, and H O the Horizon.

Secondly, Take 51 d. 30 m. the Latitude of the place, from the Line of Chords, and set it from O, to P, from H to M, from Z to E, and from N to Q and draw the Line P M for the Axis of the World or Hour-line of Six, and E Q for the Equinoctial Circle. The points ♋ and ♑ are 23 d. 30 m. (the Suns greatest declination) distant from the two Equinoctial points E and Q and the Line ♋ ♑ is the Ecliptick.

Thirdly, for the describing of the parallel of the Suns course or declination, D G K, which is 20 d. Out of the Scale of half Tangents take 20 deg. and that distance shall reach from C to G. And for the Centre of this parallel, take the Secant of 70 d. (the complement of 20 d.) and set it from G upon the Line C P extended, and that shall be the Centre of the parallel DGK.—Or the Tangent of 70 d. set from G upon the line G P extended shall also give the Centre of of that Parallel.) And in the same manner may the Parallel of Altitude A F B be described; if out of the Scale of half Tangents you take 40 d. the Suns Altitude, and set it from C to F; it shall give the Point F for the place through which that Parallel must pass, and the Centre may be found upon the Line C Z (extended, if need be) For the Suns Altitude being 40 d. the Tangent of 50 d. the Complement thereof being taken out of that Tangent Line will reach from F to the Centre of the Parallel A F B;—Or the Secant of

50 d. will reach from C to the Centre of the ſame Parallel.

Fourthly, for the deſcribing of the Meridians and Azimuth Circles, you have 3 points given whereby to deſcribe each of them: As

Z S N }
Z G N } for the two Azimuth Circles
P S M }
P X M }
and } for the three Hour Circles.
P F M }

All whoſe Centres will be found by their Tangents and Secants Complements as before.

Now by the interſections of theſe Circles of the Sphere, are deſcribed *Spherical Triangles*. As ZPS, PXO, PX G, &c. The ſides and Angles whereof may be meaſured as I have ſhewed in my 6th *Geometrical Exerciſe, performing the ſame by other meanes than there is preſcribed*, and ſhal l in this place ſay ſomething in reference thereunto. But firſt I muſt ſhew you

How to find the Pole of any Great Circle.

The Pole of every great Circle, is 90d. *diſtant from its Periferie.* Wherefore, if you take out of the Scale of half Tangents the Complement of the great Circles diſtance from the Centre of the Primitive Circle, taken upon a Line at right Angles to that great Circle, it ſhall give you upon that Line, the point of the Pole of that great Circle.

Ex-

Example. If it were required to find the Pole of the Azimuth Circle Z S N; This Azimuth Circle being distant from the Centre 19 d. 38m. take the Complement thereof 70 *d.* 22 m. out of the scale of half Tangents, and it shall reach from C to W the Pole of the Azimuth Z S a N: And so

The Pole of	P S M P F M P X M Z G N	is at the Point	T Y V J

Now in this projection

		d.	m.
CX is the Suns Amplitude from the East or West. ——		33.	20
XO his Amplitude from the North. ——		56.	40
CF the Suns Altitude when he is due East or West. ——		25.	55
C B is the hour from six. ——		39	52
B.E is the hour from Noon. ——	which measur'd upon the scale of half Tangents, will be found to contain	50.	08
C A is the *Suns* Azimuth from the East or West. ——		19.	38
a H his Azimuth from the South		70.	22
C c is the hour that the *Sun* is due East or west ——		16	50
C e is the hour of the *Suns* Rising or setting from six. —		28.	00
C G is the Suns declination. —		20.	00
G P is the *Suns* distance from the Pole. ——		70.	00
m G is the Suns Altitude at six —		15	31
C m is the Suns Azimuth from the North at six a Clock —		77.	14

		d. m.
OP is the Latitude	Which measured on the Line of cords will contain.	51. 30
PZ the complement of the Latitude.		38. 30
QK or ED the Suns declination.		20. 00
Q ♋ or Q ♑ the greatest declin.		23. 30
HD the Meridian Altitude,		58. 00
BO the Suns Altitude at the question.		40. 00

Again,

a S is the Suns Altitude, and may be thus measured;

Lay a Ruler to W the Pole of the Circle Z S N, and S, so shall it cut the primitive Circle in the point A, So is HA 40 d. of the Suns Altitude.

S P is the Suns distance from the Pole, and may be thus measured.

Lay a Ruler to T (the Pole of the Circle P S M), and S, so shall it cut the Primitive Circle in D, and DP 70 d. the Suns distance from the Pole; And in this manner may any Arch of a great Circle be measured.

II. *Upon the former Projection, to resolve several* Geographical *Problems.*

The Geographical Problems let be these following.

Prob. 1.

Prob. 1.

Two places differing only in Latitude, to find their distance.

1. Let F and G be two places, lying both under one Meridian, and both on one side of the Equinoctial, *viz.* F in the Latitude of 46 d. and G in the Latitude of 16 d. The Arithmetical way, is to substract the lesser from the greater, *viz.* 16 from 40, and the remainder 24 d. converted into miles (by allowing 60 miles to one deg.) is the distance 1440 Miles.

But to do this by the Projection,

Lay a Ruler from I the Pole of the Meridian Z G M, to F, and it will cut the primitive Circle B, and the Ruler laid from I to F will cut the Circle in f, the distance between B and f is 24 d. as before.

2. But if the places lying under the same Meridian be one on the North, the other on the South side of the Equator; as S in the Latitude of 40 d. North, and R in the Latitude of 46 d. South, these added together make 86 d. which in Miles is 5160 the distance. But by the projection.

A Ruler laid from W, the Pole of the Meridian Z S R N to the points S and R, will cut the primitive Circle in A and h, and the degrees contained between A and h, are 86 d. as before.

S Prob. 2.

Prob. 2.

Two Places differing only in Longitude, to find their distance.

1. If both the places lye under the Equinoctial, and so have no Latitude, then the degrees contained between the two places, converted into miles, is their distance. But

2. If the two places lye in some other Parallel between the Equinoctial and one of the Poles, as the two places A and S, both in the Latitude of 40 d. and differing in Longitude 70 d. 22 m. then imagine a great Circle to be drawn (by the proposition at the beginning of this *Section*) to pass through the two points A and S, whose Pole will be at O, then ther will be made a Spherical Triangle Z A S, which Triangle may be resolved by this proportion.

As the Radius 90 d.
is to the Co-Sine of the given Latitude 50 d.
So is the Sine of half the difference of Longitude; 35 d. 11 m.
To the Sine of half the distance.

Which Triangle being resolved, the distance will be found to be 22 d. 24 m. which in miles is 3144 miles. But

By the Projection.

Lay a Ruler from O (the Pole of the great Circle AS) to S, and it shall cut the primitive Circle in k; so

so shall the distance A k contain 52 d. 24 m. and the distance be 3144 miles, as before.

Prob. 3:

Two places differing both in Longitude and Latitude, to find their distance.

In this Problem there are three varieties. For

1. If one of the places lye under the Equinoctial, and have no Latitude, as I; and the other have Latitude South, as R, and differ in Longitude 78 d. the proportion in finding their distance, is this,

As the Sine of 90 d.
to the Co-Sine of the difference of Longitude 12 d
So the Co-Sine of the Latitude of R 44 d.
to the Co-Sine of the distance.

2. When the two places are on one side of the Equinoctial, as A and G, differing in Longitude 90 d. and A in the Latitude of 40 d. and G in 18 d

The Proportion is

As Radius 90 d.
To the Co-Sine of the difference of Longitude 82 d.
So the Co-Tangent of the lesser Latitude 72 d.
To the Tangent of a fourth Arch,

 Which

Which being taken out of the Complement of the greater Latitude, the remainer must be a fifth Arch. Then say

As the Co-Sine of the 4th Arch,
is to the Co-Sine of the 5th Arch;
So is the Sine of the lesser Latitude
to the Co-Sine of the distance.

3. But when the two places differing both in Longitude and Latitude do lye one on the North and the other on the South side of the Equinoctial, and differ also in Longitude, as the two places G and R,

The proportion is

As the Radius
is to the Co-Sine of the difference of Latitude,
So the Co-Tangent of one of the Latitudes
to the Tangent of a fourth Arch;
Which being taken out of the other Latitude, 90 d. being added to it, the remainer must be a fifth Arch. Then say,
As the Co-Sine of the 4th Arch,
to the Co-Sine of the 5th Arch,
So is the Sine of the Latitude first taken
to the Co-Sine of the distance.

Upon the Projection.

Arches of great Circles described through the two places given (in any Case) and the Poles of those Circles found, their distance may be obtained, as in

in the two first Problems, and as I have more at large shewed in my Eighth Geometrical Exercise.

III. *To project the Sphere in Plano, upon the Plain of the Horizon, sutable to the solution of several Problems in DYALLING.*

First, Let the primitive Circle represent the Horizon, which divide into four equal parts by the two diameters W E the Azimuth of East and West, or the Equinoctial Colure, and N S the Meridian ; and so shall the four points N, W, S, E, representing the four Cardinal points of the Horizon, East, West, North, and South, crossing each other in the centre Z, representing the *Zenith* of the place.

Secondly, For that the Pole of the World is distant from the Zenith, equal to the complement of the Latitude of the place, take therefore the Co-latitude 38 d. 30 m. out of the Line of half Tangents, and set it upon the Meridian N S from Z to P, so shall P be the North Pole of the World, and the Circle W P E the prime Vertical Circle, or Hour Line of six, whose Centre may be found by taking the Secant of 51 d. 30 m (the complement of Z P) and setting it from P to F, or the Tangent of 51 d. 30 m. and setting it from Z to F, either of which will give the Point F for the Centre of W E.

Thirdly,

Thirdly, Through the point F, draw a right Line at right Angles to N S, at the Line F, G, H, I, &c. on both ſides of F; and then making the Line F P Radius, or the Tangent of 45 d. F G ſhall be the Tangent of 15 d, and be the Centre of the Hour Circles of 5 and 7; F H ſhall be the Tangent of 30 d. and be the Centre of the Hour Circle of 4. and 8; F I ſhall be the Tangent of 45 d. equal to P F, and be the Centre for the Hour Circles of 3. and 9; and upon the Line F I (being further extended on both ſides F,) if you ſet the Tangent of 60 d. from F on both ſides, it ſhall give the Centres for the Hour Circles of 2 and 10; and the Tangent of 75 ſhall give the Centres for the Hour Circles of 1 and 11.

Fourthly, For the Equinoctial W Æ E, and the two Tropicks, ♋ and ♑, they may be thus inſerted. For that the Equinoctial Circle W Æ E is diſtant from the Zenith equal to the Latitude, take therefore 51 d. 30 m. the Latitude from the Line of half Tangents, and ſet it from Z to Æ, ſo ſhall Æ be the point of the interſection of the Meridian and Æquator; and for the Centre thereof, the Secant of 38 d. 30 m. ſet from Æ, or the Tangent of 38 d. 30 m. ſet from 21, ſhall either of them give the point M, the Centre of the Equinoctial Circle W Æ E. Then for the Tropicks of *Cancer*, and *Capricorn*, either of which are diſtant from the Æquator 23 deg. 30 m. on either ſide, add 23 d. 30 m. to 51 d. 30 m. the Sun is 75 d. which taken out of the Scale of half Tangents, ſhall reach from Z to ♑, and ſo ſhall ♑ be the point of interſection of the Tropick of Ca-

Capricorn with the Meridian.——In like manner, substract 23 d. 30 m. from 51 d. 30 m. and the remainer is 28 d. which taken out of the Scale of half Tangents, shall reach from Z to ♋, the point of the intersection of the Meridian and Tropick of *Cancer*.——The Centres of these Tropicks may be found as was that of the Æquator; for the Tangent of 28 d. set from Z will give the point L, for the Centre of the Tropick of *Cancer*; and the Tangent of 75 d. set from Z shall give the Centre of the Tropick of *Capricorn*.

The Ecliptick may be drawn through the points W ♋ E and W ♑ E, as was the Æquator; and Circles of Altitude (which are parallel Circles drawn upon the Centre Z) and Azimuths, which are right lines drawn also from the Centre Z may be described. And so is this projection also fitted for resolving all the propositions of the Sphere in reference to this Horizon; but of them I shall say nothing here, but shew how to apply this projection to Dialling.

Upon this fundamental Diogram, may any Dial plain be described, whether direct, declining, reclining, or both declining and reclining, and the two hour distances of such a Plain, be found upon the projection it self: For

1. For a Horizontal Dial;

The primitive Circle it self is an Horizontal plain, and so a Ruler laid from the pole of the plain to the several points where the Hour Circles cut the plain, shall give the true Hour distances upon such a plain. As a Ruler laid from 2 to 11 shall cut off S 11, which

which is 11 d. 50 m. and so many d. must the Hour Line of 12 be from the Hour Line of 11 on an Horizontal plain in the Latitude. A Ruler laid from Z to 10. shall cut off 24 d. 19 m. the distance of 10 a Clock from 12. And so of all the rest.

For the height of the Stile of the Dial, it is Z Æ, the half Tangent of 51 d. 30 m.

2. A Direct Erect South plain.

This plain is represented by the right Line W Z E, the Pole of which Circle is at N. Wherefore a Ruler laid to N, and to the point H, where the several Hour Circles 1, 2, 3, *&c.* cut the Line (or plain) W Z E, that Ruler shall upon the circumference of the primitive Circle, cut such degrees as are the true hour distances upon such a plain.

The height of the Stile of this Dial is the half Tangent of Z P 38 d. 30 m.

3. An *Erect Declining* Plain.

Such a plain is represented by the Line A Z B, declining from the South eastward, the quantity of the Arch BE 30 d. the Pole of which plain is at R, wherefore a Ruler laid to R, and the points where the several hour Circles cut the plain, shall upon the limb of the primitive Circle give the true hour distance S upon the plain.

The distance of the substile from the Meridian of such a plain, is where a great Circle drawn through R the Pole of the plain, and P the Pole of the world, doth

doth interſect the plain and is meaſured by the half Tangents from Z.

The height of the Stile or Pole above ſuch a plain is the quantity of that part of the Arch of that great Circle which is comprehended between P the Pole, and the place where the great Circle cuts the plain.

4. Of North and South *Recliners*.

The Circle W A E repreſents a South plain reclining 51 d. 30 m. the Pole whereof is P the Pole of the World; to which point P, if you lay a Ruler, and to the ſeveral interſections where the ſeveral Hour Circles cut the plain, they ſhall give the true Hour of diſtances upon the plain.

The height of the Stile above this plain is the half Tangent of Z P and Z Æ, which added, make 90 d. wherefore a ſtreight wyre erected in the Centre is ſufficient and all the Hour diſtances upon the plain will be equal, *viz.* each of them 15 d.

5. Of *Declining*, *Reclining* plains.

Let it be required to deſcribe upon this projection, a plain to decline from the South Eaſtward 30 d. and to recline 55 d.

1. Set 30 d. (the declination) from E to B, and draw the Line B Z A, and at right Angles thereunto the Line R Z K.

2. Out of the half Tangent Scale, take 55 d. (the Reclination) and ſet it from Z to C, and draw the Circle A C B, whoſe Centre will be at K, the Secant of 35 d, ſet from C, or the Tangent thereof ſet from

Z, And the half Tangent of 35 (the complement of the Reclination) being ſet from Z, ſhall give the point ⊙ for the Pole of the reclining plain A C B and a great Circle drawn through P the Pole of the world, and ⊙ the Pole of the plain, ſhall be the plains difference of Longitude, and this Circle is repreſented by the pricked Circle, near to the Eleven a Clock Hour Circle, namely, the Circle ✱ P ⊙✱ whoſe Pole is at V.

3. For the Hour diſtances upon the plain.

A Ruler laid at the Pole of the plain, to the ſeveral interſections of the Hour Circles, with the declining reclining plain, ſhall give upon the Limb of the primitive Circle, the Hour diſtances the upon Plain from the Meridian of the place, or 12 a Clock.

Then to find the other Requiſites belonging to this Plain, As

1. The Diſtance of the Meridian and the Horizon L B,—— A Ruler laid from ⊙ to L, ſhall cut the Circle in a, ſo B a being meaſured upon the Chords ſhall give 64 d. 41 m. for the diſtance of the Meridian and Horizon.

2. The height of the Pole above the plain PX. A Ruler laid from V (the Pole of ✱ P ⊙ ✱) to P ſhall cut the primitive Circle in c, and laid from V to X ſhall cut it in e; ſo the diſtance c e being 19 d. 25 m. is the height of the Pole or Stile above the plain.

3. The diſtance of the Subſtile and Meridian, X L. A Ruler laid from ⊙ (the Pole of the reclining plain) to L, ſhall cut the primitive Circle in a; and laid from ⊙ to X ſhall cut it in f, the diſtance a f being 6 d. 22 m. the diſtance is of the Subſtile from the Meridian.

4 The plains difference of Longitude L P X. A

Ruler

Ruler laid from P to n shall cut the primitive Circle in q, and the distance S q 17 d. 38 m. is the quantity of the Angle L P X, which is the plains difference of Longitude.

And thus have you all the requisites belonging to all sorts of Dials, and the true Hour distances upon those plains all deduced from the projection it self, the Circles whereof by their intersections make several *Spherical Triangles*, all which by the 28 Cases of Spherical Triangles may be found according to those Canons which I have delivered, for the finding of the *Requisites* in all *Dials* in my Book of Dialling in the Arithmetical part thereof.

SECT. IX.

Shewing the use of the Line of Secants, in describing a Sea Chart according to Mercators *Projection.*

BY help of this Line may a Sea Chart be made, either general, for all Latitudes (except very near the Poles) or else particular, for some designed Navigation.

Thus if you would make a General Sea Chart, so that the distance of every degree of Longitude should be one inch (for the parallels of Longitude in this projection are alwayes equal) Take one inch in your Com-

Compaſſes. and ſetting one foot in 90 d. of the *Sines*, or 90 d. of the *Secants* (which is the ſame point) the Thred there reſting, the neareſt diſtance between 10 d. and the Thred ſhall be the diſtance of the parallel of 10 d. from the Equ inoctial; and the neareſt diſtance between 11 d. and the thred ſhall be the diſtance between 10 and 11 upon the Chart. But if a little more exactneſs ſhall be required, inſtead of 10 d. take $9\frac{1}{2}$ d. for 11 take $10\frac{1}{2}$ *&c.* alwayes half a deg. leſs than the deg. you are to inſert. And thus may be made, a Sea-Chart, and it being made all ſuch concluſions in Navigatio n which concern *Longitude*, *Latitude*, *Rumb* and *diſtance*, may be wrought as I have ſhewed in part in my Geometrical exerciſes.

LAWRENCE FAIERCLOVGH 1689

Lawrence ffairclough

1680

PANOR-

PANORGANON:

The Second Part.

CONTAINING
The Uses of those Lines or Scales which are inscribed upon the Quadrantal part of the *INSTRUMENT*.

The ARGUMENT.

H*Itherto we have treated of the Uses of those* Scales *which are inscribed upon the* Sides *or* Wings *of the* Instrument: *We now come to treat of those which are inscribed upon the* Quadrantal *part, namely, the* Quadrant, *which is comprehended between the* Wings *and the* Limb *of the* Instrument. *The Description of the Lines, what they are, and the manner how to dispose them, hath been already declared in the Description of the* Instrument, *at the beginning of the* First Part; *and therefore needs not here again to be recited; and the rather, because the Names of either (or most) of them, are graduated by them, upon the* Instrument *it self.*

A a The

The Uſes that I ſhall firſt inſiſt upon, ſhall be *ASTRONOMICAL*, and ſuch as concern the firſt Motions or Courſes of the *Sun* and *Stars*; which are the principal uſes to which the *Celeſtial Globe*, and other *Spherical Inſtruments*, as *Planiſpheres*, *Quadrants*, &c. are ſubſervient to.

Now becauſe it is neceſſary to the reſolution of ſuch *Aſtronomical Problemes*, to have the true *Place* and *Declination* of the Sun at any time given (which things the Inſtrument it ſelf will ſhew, the Day of the Moneth being only known; but not with ſuch exactneſs (in reſpect of the ſmalneſs thereof) as by ſome, at all times of the Year, it may be expected) I have therefore, in the Front of this Second Part, inſerted a Table, ſhewing the Place and Declination of the Sun for every Day in the Year: The uſe whereof, followeth after the Tables.

The

Problemes Astronomical:

PERFORMED By the SCALES upon the Quadrantal part of the *INSTRUMENT*.

SECT. I.

I. *Of the two Curved Scales of Moneths.*

Prob. I.

Any Day of the Year being given, to find what other Day of the Year is of the same length therewith.

LET it be required to find what day of the Year is of equal length with the 18*th* of *October*. Lay the thred to the 18*th.* day of *October* in the lower Curve, then will the thred cut the uppermost Curve on the third day of *February*, which day is nearest of the same length with the 18*th.* of *October*; So shall you find the

1 of *March*	to be near of e-	21 of *September.*
12 of *August*	qual length with	10 of *April.*
1 of *May*	the	22 of *July.*

And ſo of any other day of the Year.

II. *Of the* Zodiack.

Prob. 2.

The Day of the Moneth being given to find the Suns place in the Zodiack.

Lay the thred to the day of the Moneth, and it will ſhew you in the Ecliptick the place of the Sun.

Let the day given be the 16*th.* of *April*, the thred laid to the 16*th.* of *April*, will cut the *Zodiack* in 6. deg. 29 min. of ♉ *Taurus*, in which Sign and Degree the Sun is upon the 16*th.* of *April.*

Note, That if you find the day of the Moneth in the upper Curve of Moneths, the Sun is in thoſe Signes that are Charactered upon the upper part of the *Zodiack*. But if you find the day of the Moneth in the lower Curve, then the Sun is in thoſe Signs that are Charactered under the *Zodiack.*

So ſhall you find that on

the 12 of *January*	the Sun will be in	2 deg. 58 m. of ♒.
the 26 of *April*		16 deg. 9 m. of ♉.
the 1 of *September*		18 d. 47 m. of ♍.
the 18 of *October*		5 d. 15 m. of ♏.

Prob.

Prob. 3.

The Place of the Sun being given to find the day of the Moneth.

LAy the Thred to the Suns place in the *Zodiack*, and it will cut the day of the Moneth either in the upper or under Curve.

So the Sun being in 18 deg. of ♎, the Thred laid thereto, will cut the 1 of *October* in the under Curve, which is the day of the Moneth. Alſo the Sun being in 13 d. 15 m. of ♉, it will cut the uppermoſt Curve in the 23 of *April*, which is the day of the Moneth.

For, If the Character of the Suns place be found under the *Zodiack*-Line, the day of the Moneth is in the undermoſt Circle; but if the Character of the Sign be above the Line, then the day of the Moneth is in the uppermoſt Circle of Moneths. cavtion

III. *Of the Arch of Declination.*

Prob. 4.

The day of the Moneth being given, to find the Suns Declination.

LAy the Thred to the day of the Moneth, and it will cut the Line of Declination (or the degrees of the equal

equal Limb counted from either ſide of 60 d.) in the Declination required.

So the day of the Moneth being the *6th.* of *May*, the Thred laid thereto, will cut the Line of Declination, (or the Limb from 60) in 19 d. 20 m. which is the Declination of the Sun Northward upon the *6th.* of *May*.

Prob. 5.

The Suns Declination being given, to find the day of the Moneth.

LAy the Thred to the Suns Declination in the Line of Declination, and it will cut the day of the Moneth both in the upper and lower Curve.

So the Suns Declination being 8 deg. South, the thred laid thereto, will cut the *16th.* day of *February*, in the uppermoſt Curve, and the *3d.* of *October* in the lower Curve, on either of which dayes the Sun hath about 3 deg. of South Declination.

And here note alſo, that if the Thred being laid to the day of the Moneth, do fall on the right hand of 60 deg. the Sun hath North Declination; but if it fall on the left hand of 60, the Sun hath South Declination.

Caution

Prob. 6.

The Suns place in the Ecliptick *being given, to find his Declination.*

LAy the Thred to the Suns place in the *Zodiack*, and it will cut the Line of Declination in the point required.

So the Sun being in 1 deg. of ♉, the Thred laid thereto, will cut the Line of Declination in 11 deg. 52 m. of North Declination, and ſuch Declination hath the Sun when he is in the firſt deg. of *Taurus*.

IV. *Of the Limb of the Quadrant.*

Prob. 7.

How to take the Suns Altitude by the Quadrant, *as alſo the Altitude of the Moon or Stars.*

BEcauſe moſt of the Propoſitions following require the Suns Altit. to be given, it will be neceſſary here to ſhew the manner how to take it at any time by the *Quadrant*, the Sun ſhining.

Upon the edge of your *Quadrant* are two Sights for this purpoſe. Take the *Quadrant* in both your hands, laying your right hand ſomewhat near that ſide that hath the Sights, and your left hand towards the other ſide, by which means you may let it ſlip lower, or raiſe it higher, as occaſion requires; then turning the left

left ſide of your Body to the Sun, hold the *Quadrant* in both your hands, as is before directed, and move it up and down in your hand till the Sun ſhining through that Sight which is next the Center of the *Quadrant*, do caſt his Ray or Beam of Light upon the Hole of the other Sight, at which inſtant look in the Limb of the *Quadrant*, what degree and parts of a degree the Thred reſteth upon; for thoſe degrees are the degrees of the Suns Altitude. Thus for taking the Suns Altitude; but for the Moon or Stars you muſt hold the *Quadrant* in both your hands, as before, and look through both the Sights, till you eſpie the Moon or Star, whoſe Altitude you require, which when you have found, looke what degrees the thred cuts in the Limb of the *Quadrant*; for thoſe degrees are the Altitude of the Moon or Star you look at.

Likewiſe in the taking of Altitudes of Buildings, *&c.* you muſt look through the Sights till you ſee (through them) the top of the Object whoſe height you would know.

V. *Of the Houre or* Azimuth *Scales*.

Prob. 8.

TO find the Hour and Minute of the Suns Riſing and Setting, with the length of the Day and Night.

LAy the Thred to the day of the Moneth, either in the upper or under Curve, ſo ſhall it cut the Scale of Hours in your reſpective Latitude, upon the juſt Hour and minute of the Suns Riſing and Setting. So

So the day of the Moneth given, being the 10*th*. of *April*, the Thred laid thereto, will cut the Line of Hours exactly in the point marked with 7, V, ſhewing that the Sun riſeth juſt at five a Clock in the Morning, as appears by V, and ſets at ſeven a Clock at night, as the Figure 7 repreſenteth.

Likewiſe, the Thred laid to the 8*th*. day of *November*, the Thred will cut the Hour-Scale at 45 min. paſt ſeven a Clock for the Sun-riſing, and at 4 a Clock and 15 min. for the Sun-ſetting.

If you double the Hours and Minutes of the Suns riſing, you have the length of the Night, and the Hours aud Minutes of the Suns Setting doubled, give the lengrh of the Day.

So on the former 8*th*. of *November*, the Sun riſeth at 7 hours 45 min. which doubled, makes 15 hours, 30 min. for the length of the night. And the Sun ſets at 4 hours 15 min. which being doubled, makes 8 ho. 30 min. for the length of the Day.

Prob. 9.

The Suns place in the Zodiack *being given, to find the Amplitude of the Suns Riſing or Setting.*

THe Amplitude of the Suns Riſing or Setting is the diſtance that the Sun riſeth or ſetteth from the true Eaſt or Weſt Points of the Horizon towards either North or South. To find this Amplitude;

Set one foot of your Compaſſes in the Point of the Zodi-

Zodiack marked with ♈ and ♎, extend the other to the Suns place in the ſame *Zodiack*, apply this diſtance of the Compaſſes to the *Azimuth*-Scale, appropriate to the Latitude in which you are, by ſetting one Foot in 90 deg. and turning the other towards the right hand in Summer, and towards the left in Winter, ſo ſhall the other Foot of the Compaſſes reſt upon the degrees of Amplitude from the Eaſt or Weſt, if you reckon the degrees included between 90 and the other foot of the Compaſſes; or elſe it gives you the Amplitude from the South if you reckon the degrees as they are numbred from the beginning of the Line.

So the Sun being in the 1 deg. of ♒; take with your Compaſſes the diſtance from ♈ or ♎ to one degree of ♒ out of the *Zodiack*; one foot of this diſtance being ſet from 90 in the *Azimuth*-Scale, the other being turned towards the left hand (becauſe it is in Winter) will reſt upon 33 d. 44 m. counted from 90, which is his Amplitude from the Eaſt or Weſt, or upon 56 deg. 16 min. counted from the beginning of the Scale, which is the Amplitude from the South, becauſe the Sun is in a Southern Sign.

In like manner, if the Sun had been in 4 deg. of ♊, the Amplitude would have been found to be 35 deg. 36 min. from the Eaſt or Weſt; or, 35 deg. 36 min. from the South, which is 54 deg. 24 min. from the North, becauſe it is Summer, and the Sun is in a Northern Sign.

Prob. 10.

THE Suns place in the Zodiack *being given, to find the Declination another way, differing from that in the* 4th, Probl.

TAke with your Compaſſes the diſtance from ♈ or ♎ to the Suns place in the *Zodiack*, apply that diſtance to the Scale of the Suns Altitude, or Line of Sines, from the beginning thereof, ſo ſhall the other foot ſhew the declination required.

So the Sun being in 29 deg. of ♉, this diſtance being taken from ♈ or ♎ out of the *Zodiack*, will reach from the beginning of the Line of the Suns Altitude, or Line of Sines, to 20 deg. and ſuch is the Suns declination Northward, becauſe the Sun is in a Northern Sign.

Prob. 11.

The Day of the Moneth (or place of the Sun in the Zodiack, *or his Declination) being given, to find the Suns Altitude at all hours.*

THis Propoſition is of ſingular uſe in the making of Inſtrumental Dials, as Equinoctial Rings, and Cylinder-Dials, as alſo in the making Quadrants and other Inſtruments that give the hour of the Day, by the

Zodiack marked with ♈ and ♎, extend the other to the Suns place in the ſame *Zodiack*, apply this diſtance of the Compaſſes to the *Azimuth*-Scale, appropriate to the Latitude in which you are, by ſetting one Foot in 90 deg. and turning the other towards the right hand in Summer, and towards the left in Winter, ſo ſhall the other Foot of the Compaſſes reſt upon the degrees of Amplitude from the Eaſt or Weſt, if you reckon the degrees included between 90 and the other foot of the Compaſſes; or elſe it gives you the Amplitude from the South if you reckon the degrees as they are numbred from the beginning of the Line.

So the Sun being in the 1 deg. of ♒; take with your Compaſſes the diſtance from ♈ or ♎ to one degree of ♒ out of the *Zodiack*; one foot of this diſtance being ſet from 90 in the *Azimuth*-Scale, the other being turned towards the left hand (becauſe it is in Winter) will reſt upon 33 d. 44 m. counted from 90, which is his Amplitude from the Eaſt or Weſt, or upon 56 deg. 16 min. counted from the beginning of the Scale, which is the Amplitude from the South, becauſe the Sun is in a Southern Sign.

In like manner, if the Sun had been in 4 deg. of ♊, the Amplitude would have been found to be 35 deg. 36 min. from the Eaſt or Weſt; or, 35 deg. 36 min. from the South, which is 54 deg. 24 min. from the North, becauſe it is Summer, and the Sun is in a Northern Sign.

Prob.

Prob. 10.

THE Suns place in the Zodiack being given, to find the Declination another way, differing from that in the 4th, Probl.

TAke with your Compaſſes the diſtance from ♈ or ♎ to the Suns place in the *Zodiack*, apply that diſtance to the Scale of the Suns Altitude, or Line of Sines, from the beginning thereof, ſo ſhall the other foot ſhew the declination required.

So the Sun being in 29 deg. of ♉, this diſtance being taken from ♈ or ♎ out of the *Zodiack*, will reach from the beginning of the Line of the Suns Altitude, or Line of Sines, to 20 deg. and ſuch is the Suns declination Northward, becauſe the Sun is in a Northern Sign.

Prob. 11.

The Day of the Moneth (or place of the Sun in the Zodiack, or his Declination) being given, to find the Suns Altitude at all hours.

THis Propoſition is of ſingular uſe in the making of Inſtrumental Dials, as Equinoctial Rings, and Cylinder-Dials, as alſo in the making Quadrants and other Inſtruments that give the hour of the Day, by the

the Altitude of the Sun. It is alſo of ſpecial uſe in putting into all ſorts of reflex Dials and others, the Signes of the Zodiack, the Parallels of the length of the Day, and other kind of Furniture for the adorning and beautifying of large Plains, of which, I ſhall have occaſion to diſcourſe more at large in another place. The Propoſition is thus to be performed:

Lay the Thred to the Day of the Moneth upon which you deſire to the know Altitude of the Sun at all hours; the thred there reſting, take with your Compaſſes the leaſt diſtance from each hour-point in the Scale of hours (anſwerable to the Latitude deſired) and meaſure thoſe diſtances upon the Line of the Suns Altitude, or Line of Sines, the number of degrees and minutes which the point of the Compaſſes reſt upon, ſhall be the degrees and minutes of the Suns Altitude at that hour.

So in our Latitude of 51 d. 30 m. If we were required to find what Altitude the Sun ſhall have at all hours upon the 12 of *Auguſt*, at which time the Sun is in the beginning of *Virgo*: Lay the Thred to the 12 of *Aug.* or beginning of *Virgo*, and keep it there; then,

Firſt, Take with your Compaſſes the diſtance from XII in the Hour-Scale to the Thred, and apply this diſtance to the Scale of the Suns Altitude, or Line of Sines, it will reach from the beginning thereof to 50 d. and ſuch is the Altitude of the Sun at 12 of the Clock upon the 12 of *Auguſt*.

Secondly, Take the leaſt diſtance from XI and 1 a Clock in the Hour-Scale to the Thred, this diſtance applied to the Line of Sines, or Scale of the Suns Altitude, gives 48 d. 12 m. for the Suns Altitude at Eleven or One of the Clock on the ſaid 12 of *Auguſt*, &c.

Do

Do the like for all the other hours of that day, and you shall find

			deg.	min.
the Suns Alt. at	X or 2	to be	43	12
	IX or 3		36	0
	VIII or 4		27	31
	VII or 5		18	18
	VI or 6		9	0

By this Rule you may make Tables for the Suns Altitude at all hours of the day, for any day of the year, or for any degree of the Sun in the *Zodiack*, or for any degree of the Suns Declination; of one of which, I have here given you an Example, which is

A Table shewing what Altitude the Sun shall have at every hour of the day, the Sun being in the beginning of each Sign, in Latitude 51 *d.* 30 *min.*

Morn. hour Aftern. hou.	XII	XI 1	X 2	IX 3	VIII 4	VII 5	VI 6	V 7	IV 8
♋	62 0	59 43	53 45	45 42	36 41	27 17	18 11	9 32	1 32
♊ ♌	58 42	56 34	50 55	43 6	34 13	24 56	15 40	6 50	
♉ ♍	50 0	48 12	43 12	36 0	27 31	18 18	9 0		
♈ ♎	38 30	36 58	32 37	26 7	18 8	9 17			
♓ ♏	27 1	25 40	[illegible] 51	15 58	8 33	0 6			
♒ ♐	18 18	17 6	13 38	8 12	1 15				
♑	15 0	13 52	10 30	5 26					

 This

This Table is of good uſe for the making of ſuch Inſtrumental Dials as I mentioned in the beginning of this Prop.

When the Sun is in the Equinoctial, there is no need of the Thred; for then you need only take the diſtance from VI to every other hour, and apply thoſe diſtances to the Scale of right Sines, and thoſe Extents there meaſured, ſhall be the Suns Altitude at thoſe reſpective hours.

Note, That whatſoever is in this *Prop.* ſaid concerning whole hours, the like is to be underſtood of parts of hours, as halves and quarters, *&c.*

Prob. 12.

The Suns place or declination being given, to find what Altitude he ſhall have when he cometh to be due Eaſt or Weſt.

TAke with your Compaſſes the diſtance from *Aries* to the Suns place in the *Zodiack*, with this diſtance of the Compaſſes ſet one foot in 90 in the *Azimuth*-Scale proper for your Latitude, then turning the other about, bring the Thred till it only touch the moveable point of the Compaſſes; then count how many degrees of the Quadrants Limb are contained between the Thred and 60 deg. for ſo many degrees high ſhall the Sun be when he is juſt upon the Eaſt or Weſt points.

So

So the Sun having 20 deg. of Declination, his place then being in 29 deg. of *Taurus*, if you take with your Compasses the distance between *Aries* and 29 deg. of *Taurus* out of the *Zodiack*, and set one foot of that extent in 90 on the *Azimuth*-Scale; if you turn the other foot about, and bring the Thred to touch the moveable point, the Thred will then cut the Limb in 25 deg. 55 min. counted in the Limb of the Quadrant from 60 towards the left hand, and such altitude shall the Sun have when he cometh to be due East or West.

Prob. 13.

The place of the Sun being given, to find what Altitude he shall have upon any Azimuth.

THis Proposition is of good use for the framing of Tables for the ready making of Instruments that shew the *Azimuth* of the Sun by the Altitude given, the working whereof differeth little from the former Prop.

For, if you take with your Compasses the distance from *Aries* to the Suns place out of the *Zodiack*, and set one foot of that distance upon the *Azimuth-Scale*, proper for your Latitude (upon that *Azimuth* on which you require the Suns Altitude) and turn the other about till the Thred only touch the moveable point, the Thred will cut in the Limb the degrees of the Suns Altitude upon the given *Azimuth*, if you count the Degrees from 60 towards the left hand.

So

So if the Sun were in the beginning of *Sagitarius*, and it were required, to find what Altitude he ſhould have when he ſhall be upon the 40 *Azimuth* from the Meridian; if you take with your Compaſſes the diſtance from *Aries* to *Sagitarius*, and ſet one foot thereof upon 40 degrees in the *Azimuth*-Scale, and bring the Thred till it only touch the moveable point of the Compaſſes, you ſhall find the Thred to reſt at 9 deg. 14 min. of the Quadrants Limb counted from 60, and ſuch is the Altitude of the Sun upon the 40*th. Azimuth* from the Meridian, when he is in the beginning of *Sagitarius*; and the like for any other *Azimuth*, or any other place of the Sun in the *Zodiack*. According to this Propoſition, it being of ſuch ſingular uſe, I have framed

A Table ſhewing what Altitude the Sun ſhall have upon every 10th. Azimuth *in the beginning of each Sign in Latitude* 51 d. 30 m.

Azimuths	♋		♊ ♌		♉ ♍		♈ ♎		♓ ♏		♒ ♐		♑	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
0	62	0	58	42	50	0	38	30	27	0	28	18	15	0
10	61	43	58	24	49	38	38	4	26	30	17	45	14	25
20	60	51	57	28	48	33	36	46	25	10	16	5	12	41
30	59	52	55	52	46	40	34	34	22	27	13	15	9	45
40	57	20	53	29	43	55	31	21	18	48	9	14	5	34
50	54	03	50	12	40	11	27	5	13	58	3	57	0	6
60	49	56	45	53	35	23	21	41	8	0				
70	44	40	40	25	29	27	15	13	1	0				
80	28	11	33	46	21	29	7	52						
90	30	38	26	10	14	25								
100	22	27	18	2	6	45								
110	14	14	9	58										
120	6	34	2	30										

In working of this *Prop.* by the Quadrant, when the Sun is in the Equinoctial, there will be no need of the use of the Compasses; for if you lay the Thred upon any number of the degrees of the *Azimuth* in the *Azimuth*-Scale, the Thred will cut the Limb of the Quadrant in the degrees of Altitude that the Sun shall have upon that *Azimuth* upon which the Thred lies, if you count the degrees of the Quadrants Limb from 60 towards the left hand.

Note, In the working of this *Proposition*, that if the Sun be in a Northern Sign, and have North declination, the moveable point of the Compasses, and the Thred must be kept and applied towards the left hand edge of the Quadrant, but when the Sun is in South Signes, towards the right hand or right edge of the Quadrant.

Prob. 14.

The Suns Altitude, and his place in the Zodiack *being given, to find his* Azimuth *from the South.*

TAke with your Compasses the distance from *Aries* to the Suns place in the *Zodiack*, and lay the Thred to the Suns Altitude, counted from 60 in the Limb of the Quadrant towards the left hand; then, setting one foot of your Compasses upon the *Azimuth*-Scales proper for your Latitude, move it gently along the same, till the other foot being turned about, may only touch the Thred; so shall the Compasse-point

rest

rest just upon the *Azimuth* from the South.

So the Sun being in the third degree of *Virgo*, and his Altitude being 35 deg. If you take the distance between *Aries* and *Virgo*, out of the *Zodiack*, and lay the Thred to 35 deg. the Suns Altitude (counted in the Quadrants Limb from 60 towards the left hand) and set one foot of the Compasses upon the *Azimuth*-Scale, and there move it along (either backward or forward) till the other foot being turned about, do only touch the Thred; so shall you find the foot of the Compasses to rest upon the *Azimuth*-Scale at 60 deg. 42 min. and that is the Suns *Azimuth*, from the South, when he is in the beginning of *Virgo*, and hath 35 deg. of Altitude. Or if you count the degrees from 90 to the place where the Compasses do rest, you shall find them to be 29 deg. 18 min. which is the Suns *Azimuth* from either East or West, according to the time of the day in which you observed the Altitude.

Prob. 15.

The Suns place together with its Altitude, being given, to find the hour of the Day.

LAy the thred to the day of the Moneth, (or to his place in the *Zodiack*) and take the Altitude out of the Scale of the Suns Altitude, or Line of Sines, with this distance; set one foot of the Compasses upon the Hour-Scale proper to your Latitude, moving the same, till the other foot being turned about, may only

only touch the Thred, so shall the Compass-point rest upon the true hour from Noon.

So the Sun being (as before) in the beginning of *Virgo*, and his altitude 35 deg. if you lay the Thred thereto, and take 35 deg. (the Suns altitude) out of the Scale of right Sines, and apply one Foot of this distance to the Hour-Scale, moving it along till the other Foot being turned about, do only touch the Thred, you shall find the Foot to rest at 3 hours, and about 7 min. from the Meridian, which shews that it is 7 min. past 3, if it be in the Afternoon; or wants 7 min. of IX, if it be in the Forenoon.

Note, That every hour (except those near 12) is divided into 15 parts or degrees, each part or degree representing four minutes of time.

Prob. 16.

To find the moment of time when the Crepusculum *or Twilight begins or ends, the Sun being in any degree of North or South Declination.*

LAy the Thred to the contrary Declination to what the Sun is in, that is to say, if the Sun have 20 deg. of North declination, then take (alwaies) 18 d. out of the Line of the Suns Altitude, or Line of Sines; and setting one Foot of that extent upon the hour-Scale, moving it along till the other only touch the Thred, the point of the Compasses will rest upon the time of the beginning or ending of the Twilight, counted from Midnight.

Thus the Sun having 11 deg. 31 min. of North declination, if you lay the Thred to 11 deg. 31 min. of South declination, and take 18 deg. out of the Scale of the Suns Altitude, moving one Foot of that extent upon the Hour-Scale, till the other touch the Thred, you ſhall find the Compaſs-point to reſt upon ſomething more than 41 min. paſt 2 in the morning, and the evening-Twilight will end at about 18 min. paſt 9 at night.

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Note here, That in Summer it may ſo fall out, that the extent of 18 deg. of the Sines will not come to touch the Thred, and reſt upon the Hour-Scale; all which time you muſt know, that there is no dark night at all; but the Twilight laſteth all night long; which here in this our Latitude of *London*, is from about the 12 of *May* to the 13 of *July*; in all which time the Sun doth not deſcend 18 deg. below our Horizon.

The End of the ASTRONOMICAL PROBLEMES.

Problemes in Dialling:

Both *UNIVERSAL* and *PARTICULAR*.

PERFORMED

By the Lines inſcribed on the Quadrantal part of the *INSTRUMENT*.

SECT. II.

A Declaration and Deſcription of the ſeveral Plains upon which Dials are to be made.

THE Lines upon the foreſide of the Inſtrument are of ſingular uſe in the uſe of *Dialing*; for by them may be made with great eaſe and exactneſs, all the moſt uſual ſorts of *Sun-Dials* in any Latitude that is deſcribed upon the Inſtrument; as all *Horizontal*, and *erect*, *direct* North, South, Eaſt or Weſt Dials; alſo all direct Eaſt, Weſt, North or South *Reclining* or *Inclining* Dials; and all *upright* Dials whatſoever, whether *direct* or *declining*: And of theſe in order.

But before I come to shew you how to make the Dials, it will be necessary to discover unto you what Plains are so, and so denominated: And therefore,

1. *An* Horizontal *Plain*,

Is such a Plain as lieth exactly parallel to the Horizon, and such are those Dials as are usually made and sold to set upon the top of a Post in a Garden, or elsewhere; the top of the Post or other thing, upon which the Dial is fixed, lying level or parallel to the Horizon of the place.

2. *An* Erect *Plain*

Is such a Plain as is perpendicular to the Horizon; as are the sides of Walls of any upright Building whatsoever; whether Tower, Steeple, House, or the like. And of these Erect Plains there are two sorts.

1. Erect direct. And,
2. Erect declining.

So,

3. *An* Erect direct *Plain*,

Is such a Plain, as being erect, or perpendicular to the Horizon as before, doth also behold, or look directly towards, either the true East, West, North or South-points of the Heavens; and all Plains that are erect or upright, and thus situate, are called *Erect direct* Plains.

4. *An*

4. *An* Erect declining *Plain.*

Is ſuch a Plain, which though it be erect or upright, doth not directly behold the true Eaſt, Weſt, North or South-points of the Heavens, but looketh obliquely, or declineth from either of thoſe points, and ſo is termed an *Erect*, but *Declining* Plain. And the Declination of ſuch Plains, is alwaies accounted from the North or South points of the Heavens, towards the Eaſt or Weſt. For, if a Wall or Plain lying open towards the South, but doth not directly behold the South, it is ſaid to decline; and if this Declination be (when you look upon the Plain) towards the right hand, the Plain is ſaid to be an *Erect Plain*, declining from the South *Eaſtward*. But if this Declination of the South be towards the left hand, the plain is ſaid to be an *Erect Plain* declining from the South *Weſtward*. And what is here ſaid of *South declining Plains*, the ſame is to be underſtood of *North-decliners* alſo; for of theſe Plains, there is only four varieties; and thoſe are,

South-declining	Eaſt	which beholdeth both the	South and the Eaſt.
	Weſt		South and the Weſt.
North-declining	Eaſt		North and the Eaſt.
	Weſt		North and the Weſt.

5. *A* Reclining *Plain.*

Is ſuch a Plain as is ſituate neither parallel or level with the Horizon, as the Horizontal Plain is; nor yet erect

erect

erect or perpendicular thereunto, as the Plains laſt deſcribed; but reclineth or bendeth from the *Zenith* of the place towards the Horizon, making an Angle therewith: And ſuch Plains as theſe, I cannot better define unto you, than by comparing them to the Roof or Covering of a Houſe, the outſide of the Tiling whereof is a *Reclining* Plain.

6. *An* Inclining *Plain.*

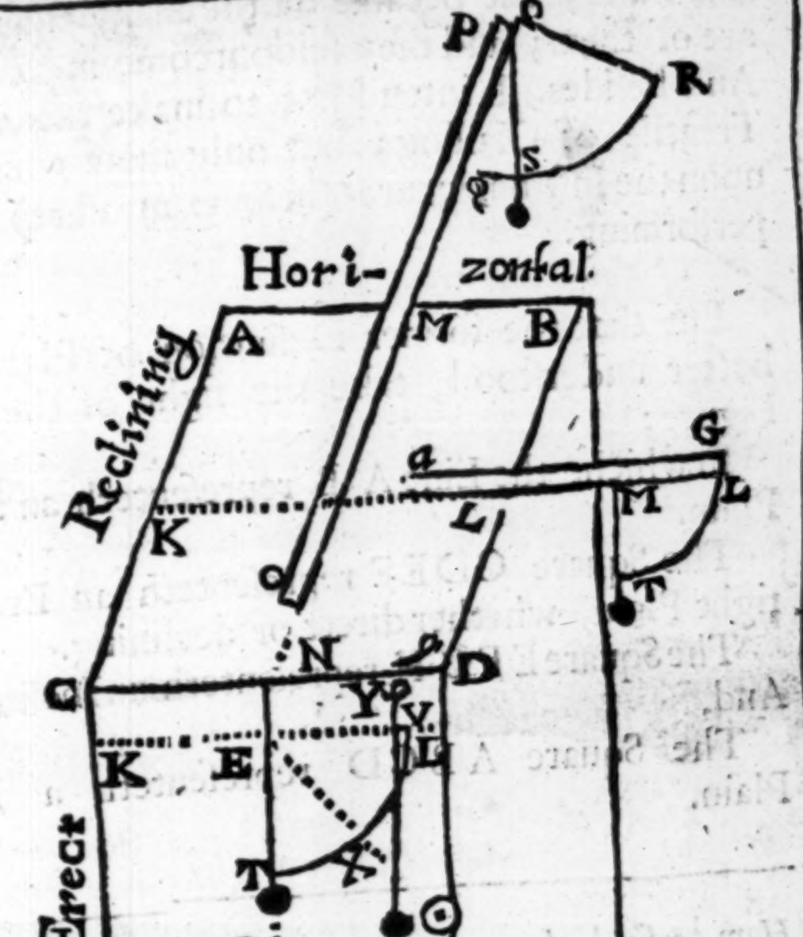
As the Reclining Plain was compared to the outſide of the Tileing or Covering of a Houſe, ſo may the Inclining Plain be alſo compared to the Inſide, or under part of the Covering of a Houſe.

Now of *Reclining* and *Inclining* Plains, there are the ſame Varieties as of *Erect Plains*; for if they do directly behold either the Eaſt, Weſt, North or South-Points of the Heavens, they are termed *Direct Recliners* or *Incliners*: But if they do not directly behold any of thoſe Points, they then decline, and are termed

South or North	Reclining	Declining Plains.
South or North	Inclining	

But of this laſt ſort of Reclining and Inclining Plains Declining, I ſhall ſay nothing in this place; not but that the Lines upon the Inſtrument will make thoſe

Dials


Hori- zontal.
Reclining
Erect
Inclining
Hori- zon
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Dials alſo; but becauſe of the many Varieties there are of them; and they ſeldom come in uſe or practiſe: And beſides, I intend not to make this an abſolute Treatiſe of Dialling; but only ſhew what the Lines upon the Inſtrument are (in ſome meaſure) capable of performing.

But that the former Definition of Plains may be better underſtood, take the ſight of the foregoing Figure:

In which, the Line A B repreſenteth an Horizontal Plain.

The Square CDEF repreſenteth an Erect or Upright Plain, whether direct or declining.

The Square E F G H repreſenteth an Inclining Plain. And,

The Square A B C D repreſenteth a Reclining Plain.

How to find the Situation of any Plain, both in reſpect of Reclination *and* Declination, *or both.*

BEfore you can make a Dial to any place or Plain propoſed, you muſt firſt know the ſituation thereof, in reſpect either of $\left.\begin{matrix}\text{Re-}\\\text{In-}\end{matrix}\right\}$clination or Declination, or both; and that ſhall be the work of this Section.

And before this $\left.\begin{matrix}\text{Re-}\\\text{In-}\end{matrix}\right\}$clination or Declination can well be attained, you muſt know

How

How to draw an Horizontal Line upon any Plain.

1. Upon ſuch a Plain as we call Horizontal (or Level) infinite Horizontal Lines may be drawn; for the Plain it ſelf being an Horizon, every Line drawn thereon is an Horizontal Line. But,

2. Upon an *Erect Plain*, ſuch as is CDEF, one Horizontal Line drawn thereon is ſufficient; and ſuch an Horizontal Line is the Line KML, which is to be drawn in this manner.---Your Inſtrument or Quadrant, having a Thred in the Centre, with a Plummet at the end of it, apply the back-ſide of your Inſtrument flat-wiſe to the Wall or Plain, moving it up or down, till ſuch time as the Thred and Plummet hang directly upon the Line MT (as is repreſented in the Figure upon the Plain CDEF,) and then by the edge of the Quadrant ML, draw the right Line KML, which ſhall be the Horizontal Line of the Erect Plain CDEF.

3. To draw this Horizontal Line upon a Reclining Plain, lay a Ruler, as *a b*, thereunto, and to the under-edge of the Ruler, apply the ſide of your Inſtrument ML, moving the Ruler and Quadrant both together, upwards or downwards, till the Thred and Plummet fall juſt upon the Line MT of the Inſtrument; then draw a Line by the ſide of the Ruler, and that ſhall be the Horizontal Line of the Plain, and is repreſented in the Scheme before-going in the Reclining Plain ABCD, by the Line KL.

4. To draw this Horizontal Line upon any inclining Plain, it is to be effected in the ſame manner as in the reclining Plain, and this Horizontal Line is repreſented by the Line KL in the inclining Plain EFGH.

How to find the RECLINATION *or* INCLINATION *of any Plain.*

LET ABCD be a Reclining Plain, and let it be required to know how much it reclineth;---- The Horizontal Line K L being first drawn, lay a Ruler, as O P, over the same, at Right Angles, or Square thereunto, the Ruler being there fast held, or fixed, apply thereto the side of your Instrument O Q, letting the Thred and Plummet hang at free liberty. And then observe what degree the Thred cutteth in the Limb of the Instrument; for the number of those degrees is the quantity of the Plains Reclination from the *Zenith*.----So in the former Figure the Thred and Plummet O S, falleth upon 20 deg. of the Quadrant, and so many degrees doth the Plain A B C D, recline from the *Zenith* towards the *Horizon*.

The Inclination of a Plain is found by applying the Instrument to the under face, or inclining Plain, and the degrees cut by the Thred in the Limb of the Instrument is the Inclination of the Plain to the *Horizon*.

How to find the Declination of a Plain.

THE Declination of a Plain, is an Arch of the Horizon intercepted, or contained, between the East or West Points of the Horizon, and the Plain. Or it is an Arch of the Horizon, contained between the North or South-Points of the Horizon, and a Line drawn perpendicular to the Plain. And this Declination

tion is alwaies accounted from the North or South Points of the Horizon towards either East or West And is thus to be attained.

To the Horizontal Line of the Plain apply one of the edges of the Instrument, so that the degrees of the Limb thereof may be towards the Sun; as the side of the Instrument ML is applied to the Horizontal Line KL of the Plain CDEF in the foregoing Figure; the Instrument thus placed, and held exactly level or Horizontal, hold up a thred with a Plummet at the end of it, so that the Sun shining, it may cast the shadow of the string exactly over the Center of the Instrument, as is expressed by the Line XM in the former Figure, and take exact notice what degrees of the Limb of the Instrument are cut of by the shadow of the Thred, accounting them from that side of the Instrument which lieth perpendicular to the Plain, as in the former Figure from T to X, and those degrees are called the *Horizontal Distance*; which Number keep.

Then at the same instant, as you take this Horizontal Distance (or assoon as may be, without the least loss of time) take the Suns Altitude, and thereby find his *Azimuth* from the North or South, by the 14*th*. *Astronomical Proposition*: And so by having the Suns *Azimuth*. and the foresaid Horizontal Distance, you may come to the knowledge of the Plains Declination, by observing the following Rules.

Having made the two former Observations of the Suns Horizontal distance, and of the Suns *Azimuth*;

Consider whether the shadow of the Thred fall between

tween the South-point of the Horizon, and that ſide of the Inſtrument which ſtandeth perpendicular to the Plain.

If the ſhadow fall between them, then the Horizontal diſtance and the *Azimuth* being added together, giveth the Declination of the Plain; and the Declination in this caſe is alwayes upon the ſame Coaſt that the Suns *Azimuth* is; that is to ſay, if the Sun be on the Eaſt-ſide of the Meridian, the Declination is Eaſterly; if on the Weſt-ſide, it is Weſterly; as in the firſt Scheme following.

If the ſhadow do not fall between the South-point, and the perpendicular ſide of the Inſtrument, then the difference between the Horizontal Diſtance and the *Azimuth*, is the Declination of the Plain. And in this caſe,

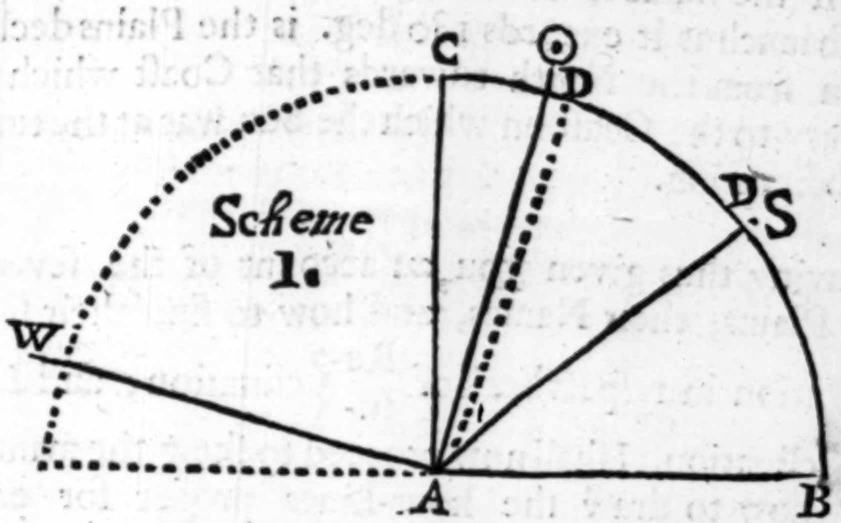
If the	Azimuth Hor.diſt.	be the greater, the Plain declineth to the	Same Contrary	Coaſt

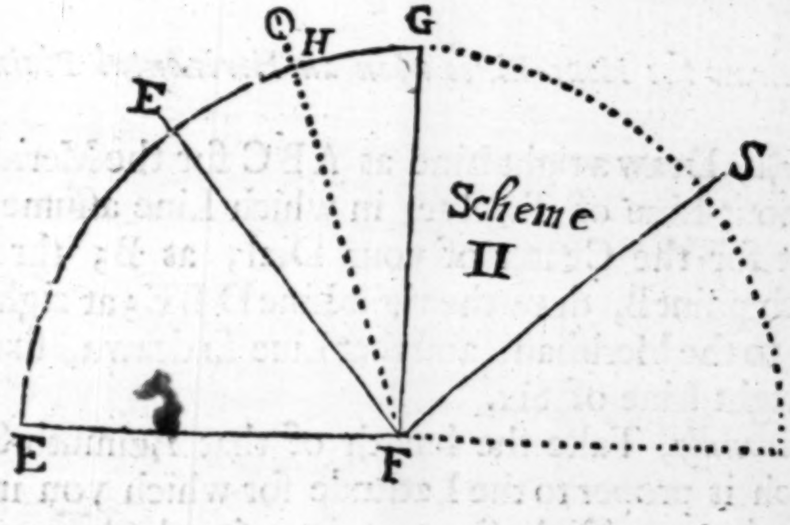
to which the Sun was on at the time of Obſervation; as appears by the ſecond Scheme.

Scheme I.	d m
Horizon. Diſtance	10--00--CD.
Azim. from South	40--00--SD.
So. Declin. Weſt	50--00--CS.

Scheme II.	d m
Horizon.Diſtance	20--00--GH.
Azim. from South	70--00--HS.
So. declin. Eaſt	50--00--GS.

And





And here note, that the Declination thus found, is alwayes accounted from the South or North towards either East or West, and must never exceed 90 deg. Wherefore observe,

3. If the number of degrees of Declination exceed 90 deg. substract it from 180 deg. and the Remainder shall be the declination of the Plain from the North, towards the Coast whereon the Sun is.

4. If

4. If the number of declination exceed 180 deg. then ſo much as it exceeds 180 deg. is the Plains declination from the North towards that Coaſt which is contrary to the Coaſt on which the Sun was at the time of Obſervation.

Having thus given you an account of the ſeveral Plains, their Names, and how to find their ſituation in reſpect both of Re- / In- clination, and Declination, I ſhall now proceed to ſhew the manner how to draw the hour-Lines proper for each Plain.

To draw the Hour-Lines upon an Horizontal Plain.

Firſt, Draw a right Line as A B C for the Meridian, and hour-Line of Twelve, in which Line aſſume any point for the Center of your Dial, as B; through which point B, draw the right Line D B E; at right angles to the Meridian, and that Line ſo drawn, ſhall be the right Line of Six.

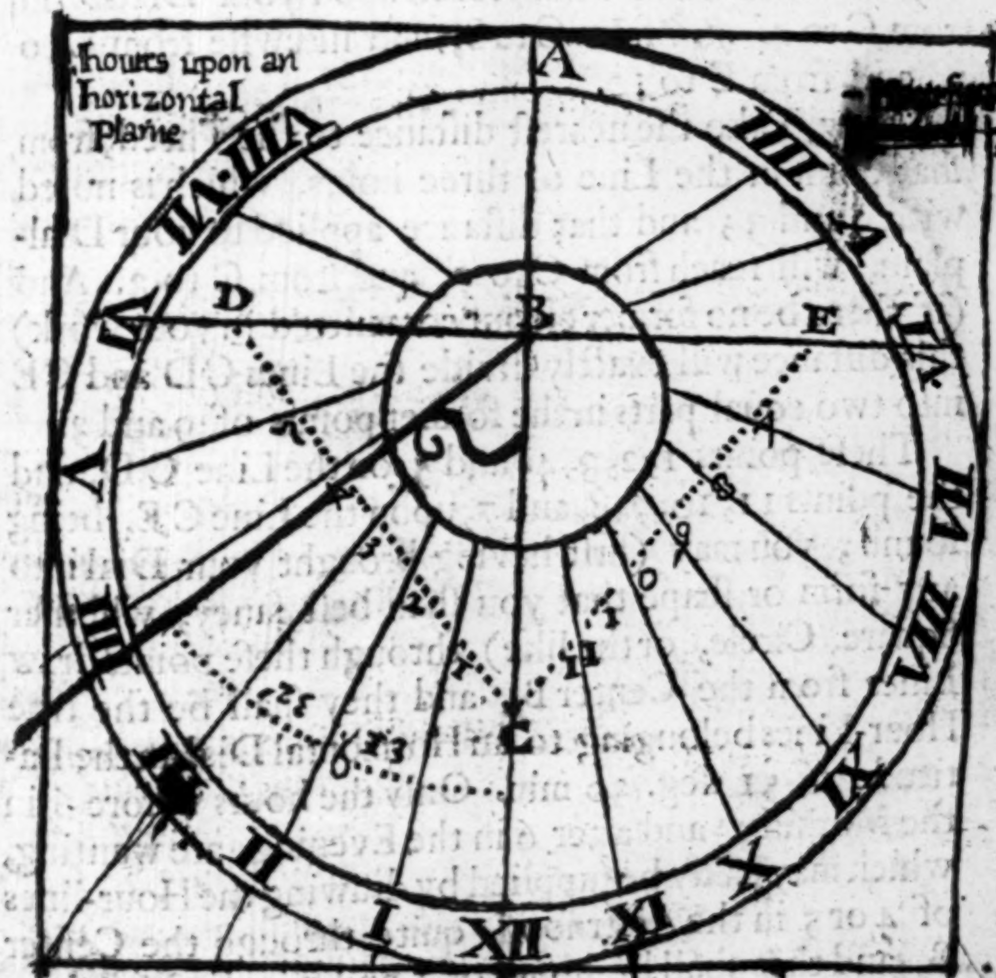
Secondly, Take the length of that Azimuth-Scale, which is proper to the Latitude for which you intend to make your Dial, from 90 deg. (or the hour of 6.) to the end thereof at 12. and ſet that length from B, the Center of your Dial, to C.

Thirdly, Take out of the ſame Azimuth-Scale the Latitude of your place counted, *viz.* 30 min. and ſet that diſtance from B to D, and from B to E, and draw the Lines C D and C E, conſtituting an Equicrural Triangle D C E.

Fourthly, Out of your Dial, take the length of your Line

Line C D or C E; for they must be of equal length, and setting one point of your Compasses in that end of the Line of three hours, which is noted with 12 and 6; bring the Thred only to touch the Compass-point as you turn it about, and keeping the Thred there;

An Horizontal Dial for the Latitude of 51 d. 30 min.



Fifthly, Set one Foot of your Compasses in that point of the Line of three hours, that is marked with 1, 5, 7, and 11; and turn the other about, till it only touch the

the Thred; this diſtance applied to your Dial-plain, will reach from C unto 5, and from C unto 7; and alſo from D unto 1, and from E to 11.

Again *Sixthly*, Set one foot of your Compaſſes in that point of the Line of three hours, that is noted with 2, 4, 8, and 10; and take the leaſt diſtance from thence to the Thred (it ſtill reſting in its former poſition) and that diſtance ſhall reach upon your Dial-plain from C to 4, and from C to 8, and likewiſe from D to 8, and from E to 10.

Laſtly, Take the neareſt diſtance to the Thred, from that point in the Line of three hours, which is noted with 9 and 3; and that diſtance applied to your Dial-plain, will reach from C to 9, and from C to 3. And (if there be no former errour committed in your work) this diſtance will exactly divide the Lines C D and C E into two equal parts in the former points of 9 and 3.

Theſe points 1, 2, 3, 4, and 5, on the Line C D, and the points 11, 10, 9, 8, and 7, upon the Line C E, being found, you may (firſt having brought your Dial into any form or ſhape that you ſhall beſt fancy, whether Square, Circle, or the like) through theſe points draw Lines from the Center B, and they ſhall be the true Hour-Lines belonging to an Horizontal Dial in the Latitude of 51 deg. 30 min. Only the hours before 6 in the Morning, and after 6 in the Evening, are wanting, which may eaſily be ſupplied by drawing the Hour-lines of 4 or 5 in the Afternoon, quite through the Center B, and they ſhall be hours of 4 and 5 in the Morning; alſo 7 and 8 in the Morning drawn through the Center, ſhall be the hours of 7 and 8 at night.

Now if you deſire to have the half hours and quarters of hours, they may be as eaſily inſerted into your

Di-

Dial, as the whole hours were. If out of the Line of three hours, you take the least distance to the Thred, from the respective points in that Line noted between each hour, and apply them to your Plain in the same manner:

For the Stile or Cock of this Dial, it may be either a Plate of Brass or Copper, or a Wyer formed to an Angle equal to the Latitude in this Example 51 deg. 30 min. as is represented in the Figure.

The Stile of these Dials must stand directly upon the Line of 12 a Clock, with the angular point thereof in the Center of the Dial at B, the which must behold the South, and the Stile-point upwards to the North-Pole.

To draw the Hour-lines upon a direct South or North-Plain.

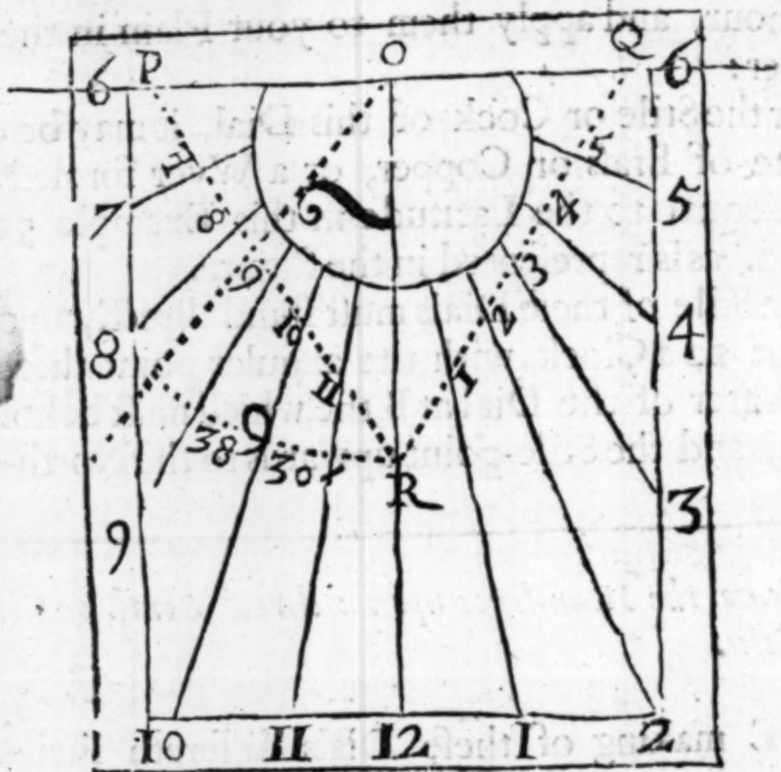
THE making of these Dials differeth little from the former; for having drawn the Line O R 12, for the Hour-line of Twelve, and made choice of O for the Center of your Dial, and through it (at right Angles) drawn the Line 6 O 6 for the Hour-line of Six.

Take the length of the *Azimuth*-Scale, proper for your Latitude from 90 deg. to the end, and set that length from O to R.

Also take out of the same *Azimuth*-Scale, the Complement of the Latitude of your place, *viz.* 38 d. 30. m. counting it from 90 deg. and set that distance upon the Six a Clock Line from O to P, and from O to Q, and draw the Lines R P and R Q.

 Then

A South-Plain in the Latitude of 51 deg. 30 min.



Then take in your Compasses the length of the Line R P or R Q, and set one foot in that end of the Line of three hours, which is farthest from the Center of the Instrument, as is marked with 6 and 12; and to that distance R P or R Q, bring the Thred to the nearest distance.

Then, from the next hour-point noted with 1, 5, 11 and 7, take the least distance to the Thred, and that extent of the Compasses will reach from R to 7, and from R to 5; and also from P to 11, and from Q to 1.

Again, the nearest distance taken from the hour-point, noted in the Line with 2, 4, 8 and 10, to the Thred,

Thred, will reach from R to 8 and 4, and from P to 10, and from Q to 2.

And lastly, the nearest distance taken from the point in the Line, noted with 9 and 3, to the Thred, will reach from R to 9, and from R to 3; and (if there be no errour) divide the Lines R P and R Q each of them, into two equal parts.

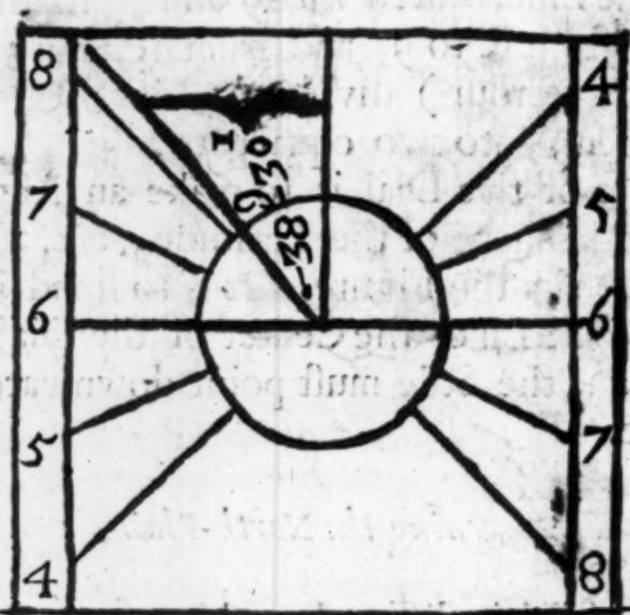
The Stile of this Dial is to make an Angle equal to the Complement of the Latitude, *viz.* 38 d. 30 m. as is to be seen in the Figure. It is to stand just upon the 12 a Clock Line, the Center of the Dial must be upwards, and the Stile must point downwards to the South Pole.

Concerning the North-Plain.

The North-Plain differeth nothing from the South; for having made the one, you have made the other also; the Line of 6 a Clock being the same in both, and the hour-lines of 4 and 5 in the Afternoon being drawn through the Center, will be the hour-Lines of 7 and 8 at night, and the hour-lines of 7 and 8 in the Morning, drawn through the Center, will become the hour-lines of 4 and 5 in the Morning.

The Stile of this Dial must point upwards, towards the North Pole, and make an Angle equal to the Complement of the Latitude, *viz.* 38 deg. 30 min. as the Stile of the South Dial did; all which things are visible in the Scheme following.

A North-Dial in the Latitude of 51 deg. 30 min.



To draw the Hour-Lines upon a direct East or West-Plain.

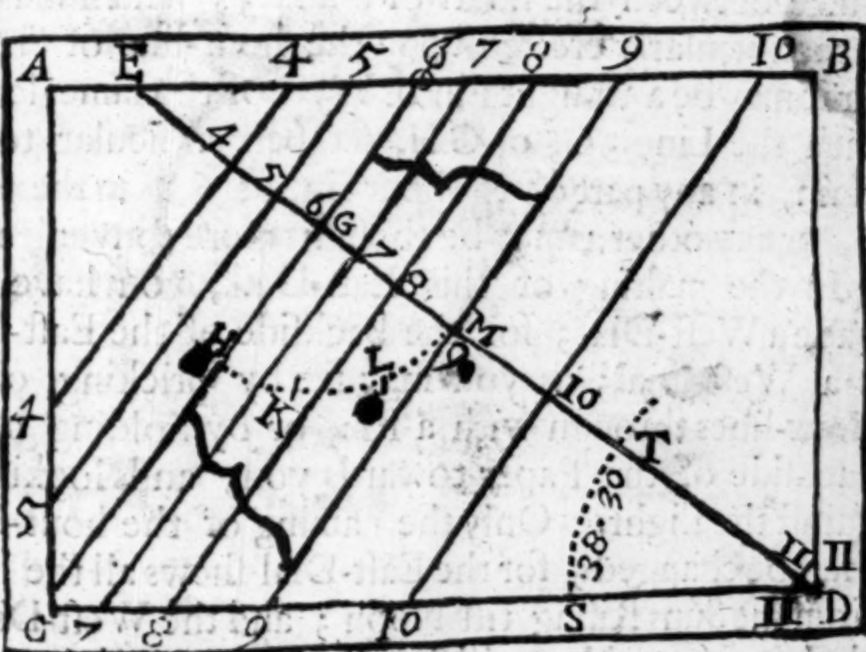
THE Dial that we shall here produce for our Example, shall be an erect direct Plain, beholding the East, in the Latitude of 51 deg. 30 min.

Let A B C D be such a Plain, upon the angular point D, describe an arch of a Circle S T, and set off upon it 38 deg. 30 min. equal to the Complement of the Latitude from S to T, and draw the Line D E for the Equinoctial Line.

Upon this Line assume any poinr, as G, for the place of the Six a Clock hour-line, and draw the Line H G⊙ at right Angles to the Line E D, which Line shall be the hour-line of Six; and the Line upon which the Stile of the Dial must stand. Upon

Upon the point G (at such distance as you would have the height of the Stile to be, *viz.* G H) describe the Quadrant H K L M, and make G ⊙ equal to G H; and also set the distance G H from H to L, and from M to K.

An East-Dial in the Latitude of 51 *deg.* 30 *min.*



This done, a Ruler laid from ⊙ to K, shall give the point 7, upon the Line E D, for the hour-point of 7; and a Ruler laid from ⊙ to L, shall give the hour-point of 8. The point M is the hour-point of 9. Again, the distance from 9 to 7, shall be equal to M 10; for the hour-point of 10, and the distance from M to G, being set twice from 10, shall give the hour-point of 11, and so right lines drawn through the several points

7, 8, 9, 10, and 11, all parallel to the hour-Line of six, shall be the true hour-lines of 7, 8, 9, 10, and 11 a Clock. Then for the hour-points of 4 and 5 in the Morning, the distance from G to 8, is equal to G 4; and G 7, equal to G 5; and so Lines drawn through those points, parallel to Six, shall be the hour-lines of 4 and 5 in the Morning.

The Stile of this Dial may be either a Plate of Brass, or the like, of the same breadth with the distance between the hours of 6 and 3; which must be perpendicularly erected upon the hour-line of Six.---- Or it may be a straight Pin or Wyer of the same length with the Line ⊙G, or G H, set perpendicular to the Plain, in any part of the hour-line of 6, as in the point G, or any other as may be thought more convenient.

In the making of this East-Dial, you have also made a West-Dial; for the backside of the East-Dial, is a West-Dial; as you may see by pricking of the Hour-lines through with a Pin, or by holding of the backside of the Paper towards you, and looking against the Light. Only the naming of the hour-Lines must be changed; for the East-Dial shews all the hours from the Suns Rising till Noon; and the West-Dial all the hours from Noon till Suns Setting: And therefore,

The Hour-line of	in the Morning in the East-Dial, must be	in the Afternoon in the West-Dial.
	4	8
	5	7
	6	6
	7	5
	8	4
	9	3
	10	2
	11	1

The

The Stile must be of the same height, and must stand upon the hour-line of Six, as in the East.

And here note, that these five Dials, *viz.* the Horizontal, South, North, East and West, may be made upon a Cube, or Stone, cut Square in form of a Die; for, the Horizontal Dial being upon the top, or uppermost flat, the South-Dial must be upon that flat which lies before the Center or Point of the Horizontal Dials Stile; the North Dial on that flat opposite to it; and when you look upon the South-Dial, the East-Dial must be upon the right hand flat, and the West-Dial upon the left hand flat, opposite thereunto: the sixth flat must be the Basis, upon which the Cube or Body must stand.

And note further, that when these Dials are thus truly disposed, upon such a Stone; and all the Stiles, or Cocks, rightly placed in each Dial, you shall see that the edges of all the Stiles, in all the Dials, will be parallel one to another; and all of them parallel to the Axis of the world (which the Stile of every Dial representeth) one end pointing upwards towards the North, and the other downwards, towards the South-Pole. And so in all bodies of Dials, consisting of any number whatsoever; if the Dials be truly made, and the Stiles rightly placed, they will all of them be parallel one to another. This is a good Caution, and ought to be minded; for it will be assistant to you in the true disposing of variety of Dials upon several Plains.

A good Caution

a good Caution

Lawrence-faierclough at ye corner of woodstreet in cheapside

Ano Dom- [illegible]82

How

Lawrence Faierclough 10th Novem: 169[illegible]
But now in Milkstreet Near Cheapside

How to draw a Meridian Line upon any Horizontal Plain, whereby to ſet any Horizontal or other Body of Dials in a true poſition anſwerable to the Eaſt, Weſt, North and South-Points of the Heavens.

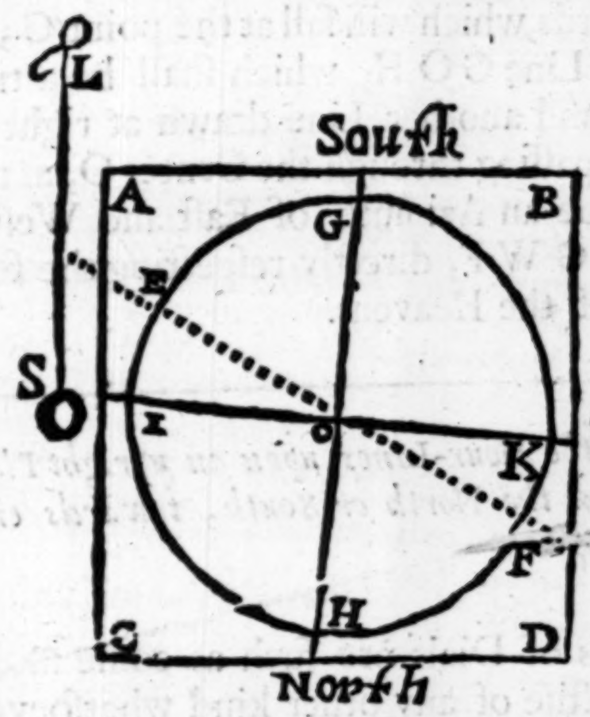
A Meridian Line is ſuch a Line, as being drawn upon any flat, level, or horizontal Plain; the one end thereof directeth to the true North, and the other to the true South-points of the Horizon.

The finding of ſuch a Line is oftentimes performed by placing a Needle touched with a Loadſtone, ſuch as is uſual in Sun-Dials for the Pocket; but thoſe Needles are ſubject to variation, and the beſt of them to be attracted by any Iron being near; ſo that we ſhall reject that way; and ſhew how it may be more artificially performed.

Having prepared your Plain, upon which you would place your Dial, and made it very ſmooth, and ſet it exactly level with the Horizon; find the Center of the Plain, and upon the Center deſcribe a Circle: Then hold up a Thred and Plummet, till the Shadow paſs through the Center of the Circle, and then in the Line of the Shadow make two marks with a Black-Lead Pencil, or other point; and at the ſame time by Pag. 5 the 7*th*. Probleme of the firſt Section of this ſecond Part: Take the Suns Altitude with your Inſtrument, Pag. 15 and by the 14*th*. Probl. of the ſame, find the Suns *Azimuth*, from the Eaſt, Weſt, North or South; which obtained, come to your Plain, and with your Compaſſes out of a Line of Cords take the *Azimuth* as you found it to be; and ſet it upon the Circle towards its

true

true Coast, either from the North or from the South; so a right Line drawn from this point through the Center, shall be a true Meridian Line, and another Line drawn at right Angles to this, through the Center also, shall be a true *Azimuth* of East or West.



Example.

Let ABCD be the top of a Post, Pedestal, or other Horizontal Plain, upon which you would draw a Meridian Line.

First, Upon the Center O, describe the Circle IGKH; then holding up a Thred and Plummet, as LS, so that the Sun shining, it may cast the shadow of the Thred through the Center of the Circle O, which Line of Shadow is represented by the Line EOF.

Secondly, The Suns Altitude being taken, and his

Azimuth found by the forementioned 14th. Probl. to be 65 deg. 30 min. short of the South, towards the East, because the Observation was made in the Forenoon; take these 65 deg. 30 min. out of the same Line of Cords by which you described the Circle, and set that distance upon the Circle from the Line of Shadow at E Southwards, which will fall at the point G; wherefore draw the Line G O H, which shall be a true Meridian-line; and another Line drawn at right Angles thereto, and passing through the Center O, as the Line I O K, shall be an Azimuth of East and West, these four points I G W F, directly respecting the four Cardinal points of the Heavens.

How to draw the Hour-Lines upon an upright Plain, declining from the North or South, towards either the East or West.

These sorts of Dials are such as come most in use and practise of any other kind whatsoever, they being such as are made against the Sides of Steeples, Walls, or other upright Buildings. And before the Hour-lines can be drawn upon these Plains, there must three things be known; *viz.*

1. The quantity of the Plains *Declination* from the North or South towards either East or West.
2. The *Deflection* or distance of the Substile from the Meridian.
3. The *Height* of the *Pole* (or *Stile* of the Dial) above the *Plain*.

The manner how to find the *Declination* of any Plain hath been already taught in this Section; wherefore we will proceed to the finding of the other two; *viz.*

1. The Deflection or Substiles distance from the Meridian.
2. The Height of the Pole or Stile above the Plain.

For Example then.

Suppose that in the Latitude of 51 deg. 30 min. an upright Wall or Plain should decline from the South 26 degrees, towards the West, this Plain must be called *A South Plain declining Westward* 26 *deg.* And the manner how to find the *Requisites*, and to draw the *Hour-Lines* upon such a Plain, shall be the work of the three following Paragraphs.

I. How to find the Deflection, or the Sub-Stiles distance from the Meridian, or Hour-Line of 12.

LAy the Thred of your Instrument to the degrees of your Plains Declination, counted in the Azimuth-Scale proper to the Latitude for which you make your Dial, from 90 deg. Then will the Thred cut in the Limb of the Instrument, the number of degrees of the deflection, or Sub-stiles distance from the Meridian; if you count the same degrees in the Limb towards the left hand from 60 deg.

Thus, the Declination of this Plain being 26 deg. count 26 deg. upon the Azimuth-Scale from 90, That is,

is, 64 deg. from the beginning of the Scale) and the Thred will cut in the Limb of the Instrument 19 deg. 13 min. the degrees being accounted from 60; and these 19 deg. 13 min. is the Deflection, or Sub-stiles distance from the Meridian.

II. *How to find the height of the Pole or Stile above the Plain.*

OUt of the Azimuth-Scale proper to your Latitude, take with your Compasses from 90 deg. the distance to the Plains declination, that distance being measured upon the Scale of the Suns Altitude, or Line of Signes from the beginning thereof, will give you the height of the Pole or Stile above the Plain.

Thus, the Declination of the Plain being 26 degr. set one foot of the Compasses into 90 deg. of the Azimuth-Scale, proper to your Latitude, and extend the other to 26 deg. (the Plains declination) counted in the same Scale, this distance of the Compasses being applied to the Scale of the Suns Altitude, or Line of Signes, will reach from the beginning thereof to 34 d. 1 min. and such is the height of the Pole or Stile above the Plain.

III. *How to draw the Hour-Lines upon the Plain.*

First, DRaw a right Line A D, for the Meridian, or Hour-line of 12. and assign the point A for the Center of your Dial, through which point, draw the Horizontal Line B A C, perpendicular to 12.

Secondly,

Secondly, Upon the Center A (with any line of Cords) describe an Arch of a Circle HKL, (on the right side of the line of Twelve, because the Plain declines Westward; but on the left side of Twelve, if the Plain had declined Eastward.) Upon which Arch set off 19 deg. 13 m. the distance of the Sub-stile from the Meridian, from H to K, and draw the Line AK for the Sub-stile. Also set off 34 deg. 1 min. the height of the Stile from K to L, and draw the Line AL for the Stile.

Thirdly, Take with your Compasses out of the Latitude-line, from the beginning of it to the Latitude of your place for which you make your Dial, *viz.* 51 d. 30 m. and set that distance upon the Horizontal Line of your Plain, from A to E, and through the point E draw the Line EG, parallel to the Meridian or Line of 12.

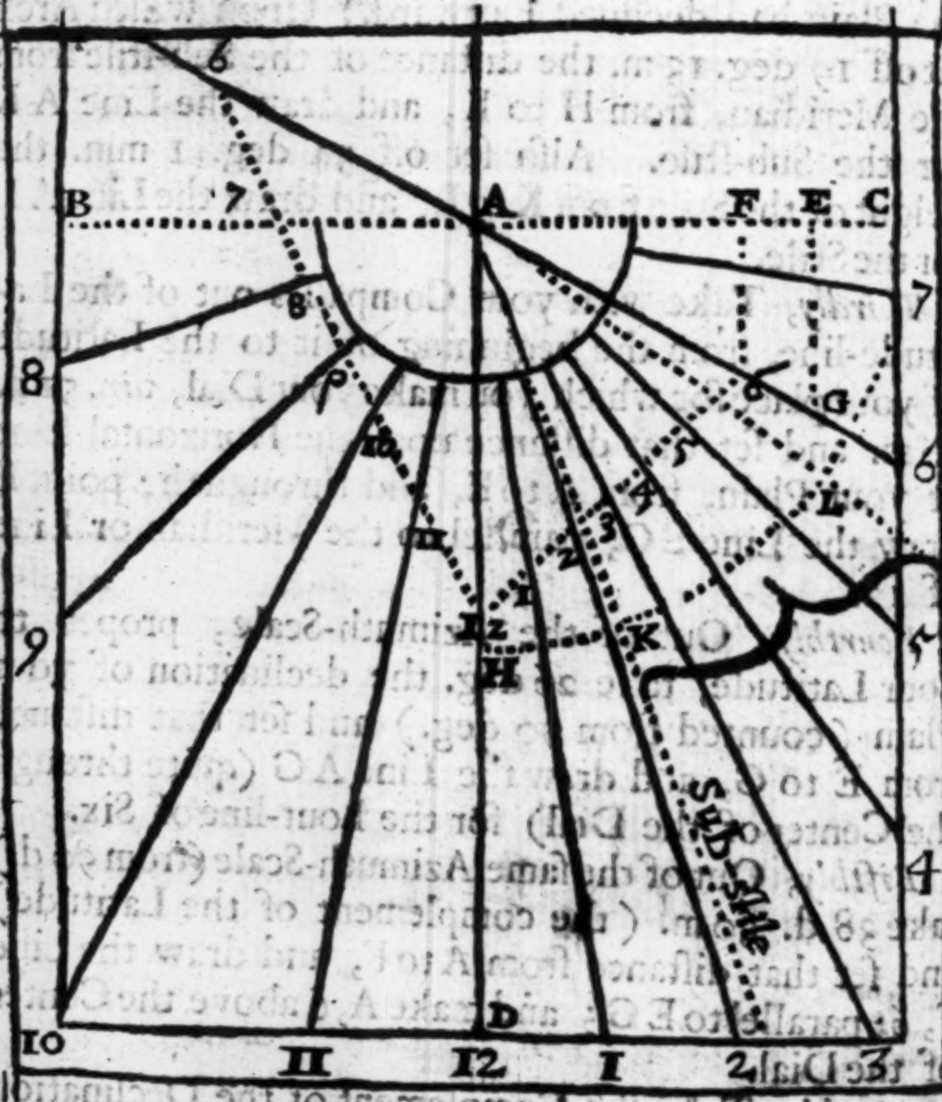
Fourthly, Out of the Azimuth-Scale, proper to your Latitude, take 26 deg. the declination of your Plain (counted from 90 deg.) and set that distance from E to G, and draw the Line AG (quite through the Center of the Dial) for the hour-line of Six.

Fifthly, Out of the same Azimuth-Scale (from 90 d.) take 38 d. 30 m. (the complement of the Latitude) and set that distance from A to F, and draw the Line F, 6, parallel to EG; and make A, 6 above the Center of the Dial.

Sixthly, Take the Complement of the Declination of the Plane 64 deg. out of the Azimuth-Scale, counted from 90, or take from 90, to the Declination it self, which is all one; and set that distance upon the Meridian from A to 12, and draw the two Lines 12, 6 and 12, 6 on either side of the Meridian.

Seventhly,

A South-Dial declining Westward 26 deg. in the Latitude of 51 deg. 30 min.



Seventhly, Take the longest of the Lines 12, 6, in your Compasses, and setting one foot of the Compasses in the end of the Line of 3 hours, noted with 12, 6; bring the Thred to the nearest distance: The Thred

Thred thus resting, set one foot of the Compasses in that point of the Line of three hours that is marked with 7, 11, and from it take the nearest distance to the Thred, so shall it give you the distance from 12 to 7, and from 6 to 11. Again, take the nearest distance from the point in the Line of three hours, noted with 8, 10, and the Thred, and that shall reach from 12 to 8, and from 6 to 10.----Also the nearest distance from the point 9, 3, in the Line of three hours, and the Thred shall give you the distance 12, 9, or 6, 9, dividing the Line 6, 12 into two equal parts: So shall the points 7, 8, 9, 10, 11, be the points through which the hour-lines of 7, 8, 9, 10 and 11 must pass; only the hour-point of 7 in the Morning, being above the Horizontal Line of the Plain, must be drawn through the Center of the Dial, and become the hour-line of 7 at night, on the other side of 12 a Clock.

Lastly, Take the shorter of the two Lines 12, 6, and setting one foot in the end of the Line of three hours, noted with 6, 12; bring the Thred to the nearest distance, and taking the respective distances from the several points in that Line, it shall give you the points 1, 2, 3, 4, and 5 in the Line 12, 6, through which points the hour-lines of 1, 2, 3, 4, and 5 must be drawn, and so is your Dial finished.

Only, the Stile must be set upon the Sub-stile perpendicular to the Plain:

But making an angle with the Sub-stile of 34 deg. 1 min.

And in making of this Dial you have made 4 Dials, *viz.*

A South declining East
North declining West / East } 26 degrees.

For the Paper upon which a South-declining-West-Dial is made, being turned, and held against the Light, becomes a South-declining-East; only the Fore-noon-hours in the one Dial, must be Afternoon-hours in the other; and the contrary. Also,

The Hours of a South-West- / South-East- Dial being drawn through the Center, becomes a North-East. / North-west.

Only the Hours must be changed, and those Hours about the Meridian (which in the North-declining Dials represent 12 at Midnight) must be wholly omitted, as 12, 11, 10, and 9 a Clock, must be quite left out; and as the Stiles of the South decliners pointed downwards to the South Pole, so the Stiles of the North decliners must point upwards to the North Pole.

And if the North Plains do not decline many deg. some hours both of the Morning and Evening must be inserted upon them, as you may see by the direct North Dial before.

And in a North declining East Dial 26 deg. besides the hours of 4, 5, 6, 7, 8 and 9 in the Morning, there must be inserted the hour-lines of 7 and 8 at night.

And in the West decliner 26 deg. there must be inserted

ſerted beſides 3, 4, 5, 6, 7 and 8 in the Afternoon, 4 and 5 in the Morning.

And becauſe theſe Dials of all others, are the moſt uſual, I will therefore inſert one other Example of a Plain-declining 45 deg. in the Latitude of 51 d. 30 m. in which I will expreſs all the forementioned Varieties.

For the manner of finding the Requiſites, as the Sub-ſtiles diſtance from the Meridian, and the height of the Stile, it is to be performed as in the other declining Plain; and by ſo working as is there directed, you ſhall find,

	d.	m.
The diſtance of the Sub-ſtile and Merid.	29	20.
The height of the pole above the Plain,	26	6.

Which things being known, you may proceed to the making of the Dial in all reſpects as the former: So that in this Place I ſhall only give you a ſight of the Figure, leaving the reſt to your own practiſe.

A South declining Eaſt }
North declining { Weſt / Eaſt } 26 degrees.

For the Paper upon which a South-declining-Weſt-Dial is made, being turned, and held againſt the Light, becomes a South-declining-Eaſt; only the Fore-noon-hours in the one Dial, muſt be Afternoon-hours in the other; and the contrary. Alſo,

The Hours of a { South-Weſt- / South-Eaſt- } Dial being drawn through the Center, be-comes a { North-Eaſt. / North-weſt.

Only the Hours muſt be changed, and thoſe Hours about the Meridian (which in the North-declining Dials repreſent 12 at Midnight) muſt be wholly omitted, as 12, 11, 10, and 9 a Clock, muſt be quite left out; and as the Stiles of the South decliners pointed downwards to the South Pole, ſo the Stiles of the North decliners muſt point upwards to the North Pole.

And if the North Plains do not decline many deg. ſome hours both of the Morning and Evening muſt be inſerted upon them, as you may ſee by the direct North Dial before.

And in a North declining Eaſt Dial 26 deg. beſides the hours of 4, 5, 6, 7, 8 and 9 in the Morning, there muſt be inſerted the hour-lines of 7 and 8 at night.

And in the Weſt decliner 26 deg. there muſt be in-

ſerted

ſerted beſides 3, 4, 5, 6, 7 and 8 in the Afternoon, 4 and 5 in the Morning.

And becauſe theſe Dials of all others, are the moſt uſual, I will therefore inſert one other Example of a Plain-declining 45 deg. in the Latitude of 51 d. 30 m. in which I will expreſs all the forementioned Varieties.

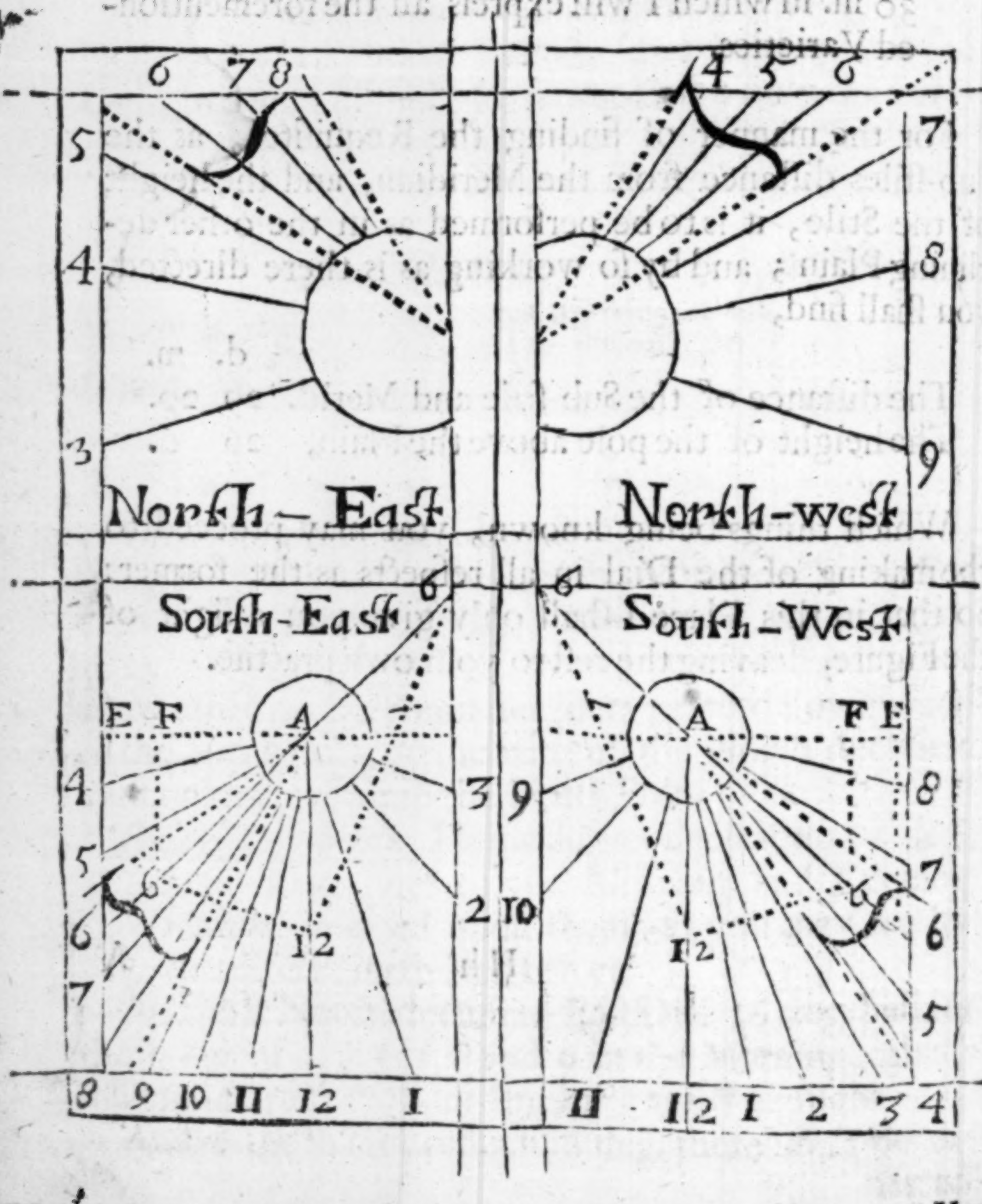
For the manner of finding the Requiſites, as the Sub-ſtiles diſtance from the Meridian, and the height of the Stile, it is to be performed as in the other declining Plain; and by ſo working as is there directed, you ſhall find,

	d.	m.
The diſtance of the Sub-ſtile and Merid.	29	20.
The height of the pole above the Plain,	26	6.

Which things being known, you may proceed to the making of the Dial in all reſpects as the former: So that in this Place I ſhall only give you a ſight of the Figure, leaving the reſt to your own practiſe.

A South / South / North / North Plain declining East / West / East / West 45 degrees.

In the Latitude of 51 deg. 30 min.



How to draw the Hour-Lines upon an upright declining Plain, which in respect of the greatness of the Declination, theCennter of the Dial must be omitted.

SUch Plains as do decline many degrees from the North or South, towards either the East or West, (as above 60 deg.) the height of the Pole above these Plains, will be but of small Elevation; by means whereof, the hour-lines (except they be extended a very great distance from the Center, they will be of no sensible distance one from another; wherefore the old usual way was, to draw the Dial upon the Floor of some large Room, and at a convenient distance from the Center, to cut off the hour-lines Stile and Sub-stile. But this way being too Mechanical, and liable to very much uncertainty, I will here shew you an artificial way, whereby you may draw a Dial of the greatest declination within the quantity of a quarter of a Sheet of Paper, wherein the Stile shall have a sufficient height above the Sub-stile, and the hour-lines a competent distance one from another.

Wherefore let us suppose in this our Latitude of *London*, 51 deg. 30 min. an upright South Plain to decline from the South towards the East 83 deg. 37 min. Before you come to the drawing of the hour-lines, you must as before, find,

1. The height of the Pole above the Plain.
2. The Sub-stiles distance from the Meridian. And in these for Decliners.
3. The Plains difference of Longitude.

All which may be found by the Instrument, as followeth.

 I. To

I. *To find the height of the Pole or Stile above the Plain.*

TAke with your Compasses out of the Azimuth-Scale proper to your Latitude, the distance from 90, to 83 deg. 37 m. your Plains Declination; this distance being applied to the Scale of the Suns Altitude, or Line of Signs, will reach from the beginning thereof to 3 deg. 58 min. the height of the Pole or Stile above the Plain.

II. *To find the distance of the Sub-Stile from the Meridian.*

BRing the Thred to 83 deg. 37 m. the Plains declination in the Azimuth-Scale proper for your Latitude, counted from 90 deg. then will the Thred in the Limb of the Instrument rest upon 38 deg. 18 min. If you count the degrees from 60, towards the left hand, and these 38 deg. 18 min. is the deflection, or distance of the Sub-stile from the Meridian.

III. *To find the Plains difference of Longitude.*

BRing the Thred to 83 deg. 30 min. the Plains declination, counted in the Azimuth-Scale, from the beginning thereof, so shall the Thred rest in the Limb of the Instrument upon 5 deg. the Complement

whereof

whereof is 85 d. which is the Plains difference of Longitude.

Having found these three Requisites, *viz.*

	d.	m.
The height of the Stile above the Sub-stile	03	58.
The distance of the Sub-stile and meridian	38	18.
The Plains difference of Longitude	85	00.

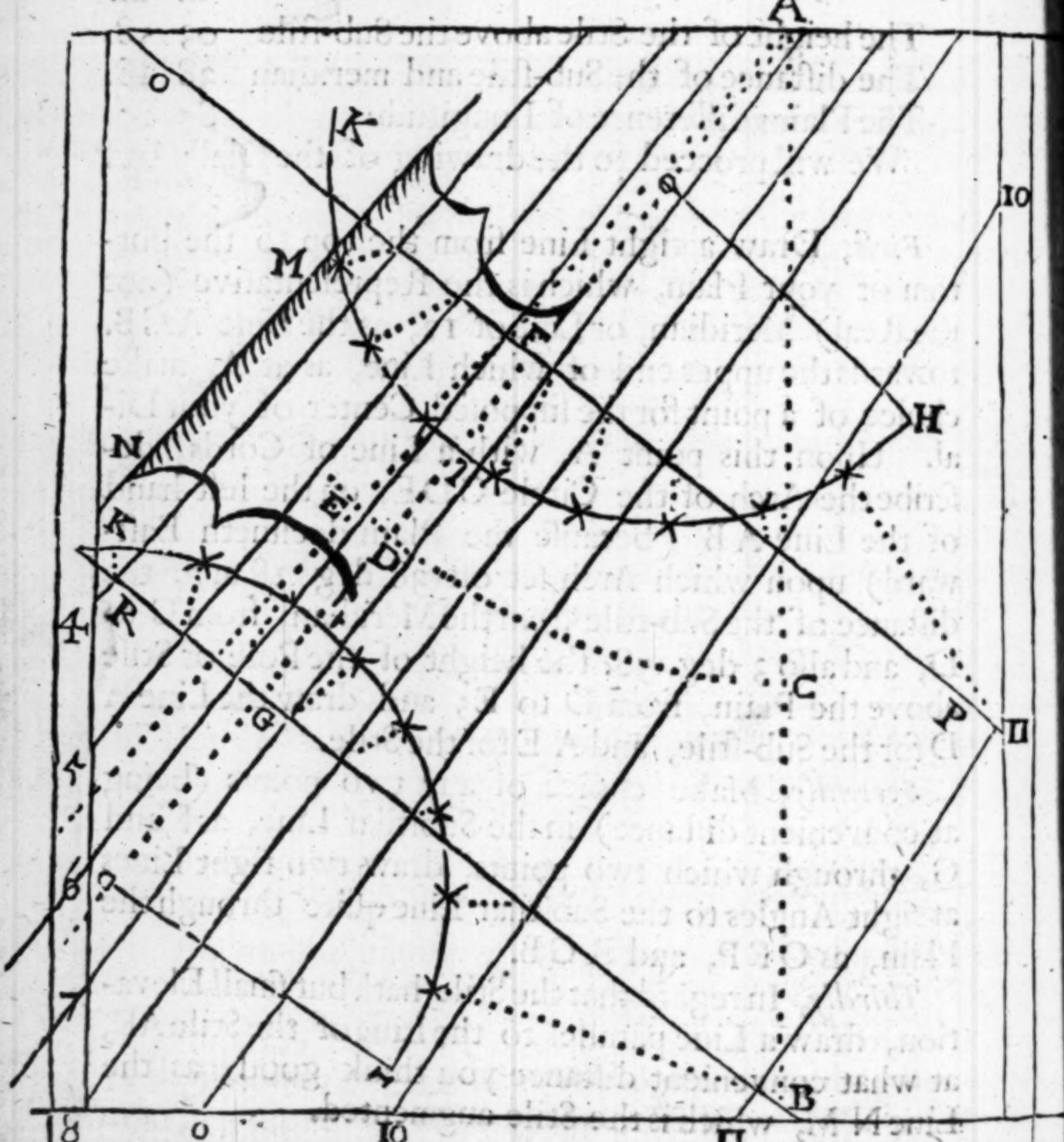
We will procced to the drawing of the Dial; And

First, Draw a right Line from the top to the bottom of your Plain, which is the Representative (not the Real) Meridian, or Line of 12, as the Line A C B. towards the upper end of which Line, as at A, make choice of a point for the supposed Center of your Dial. Upon this point A, with a Line of Cords, describe the Arch of the Circle C D E, on the left hand of the Line A B (because the Plain declineth Eastward) upon which Arch set off 38 deg. 18 min. the distance of the Sub-stile from the Meridian, from C to D, and also 3 deg. 58. the height of the Pole or Stile above the Plain, from D to E; and draw the Line A D for the Sub-stile, and A E for the Stile.

Secondly, Make choice of any two points (being at convenient distance) in the Substilar Line, as F and G, through which two points, draw two right Lines at right Angles to the Substilar Line quite through the Plain, as O F P, and R G B.

Thirdly, In regard that the Stile hath but small Elevation, draw a Line parallel to the Line of the Stile A E, at what convenient distance you think good, as the Line N M, which is the Stile augmented.

A South-Plain declining Eastward 83 deg. 30 min. in the Latitude of 51. deg. 30 min.



Fourthly, From the point F, take with your Compasses the least distance to the Augmented Stile M N, and set that distance upon the Substilar Line from F to ⊙. Also from the point G, take the least distance to the augmented Stile M N, and set that distance upon the Substilar Line, from G to ⊙ also.

Fifthly, Upon these two points ⊙ ⊙ last found, with any Line of Cords, describe two Arches of Circles, as H I K, and H I K; and then out of your Line of Cords take 85 deg. the Plains difference of Longitude, and set that distance from I to H upon both the Arches, on that side as the Line A C B that the representative Meridian standeth.

Sixthly, From the points H and H in both the Arches, begin to divide the Arches into hours, by taking 15 d. out of the Line of Cords, and setting that distance from H, to the points * * *, *&c.* upon both the Arches. Then to the points ⊙ ⊙ lay a Ruler, and where the Ruler crosseth the Lines O P and K B make marks.

Lastly, A Ruler laid from point to point in the two Tangent Lines, each to its Correspondent, right lines drawn through these points, shall be the true hour-lines for such a declining Plain.

The Stile may be either a Rod of Iron, or a Plate of Brass or Copper set at right Angles to the Sub-Stile, and inclining towards the Center with an Angle of 3 deg. 58 min. answerable to the height of the Stile above the Plain. And in this Dial you have made four Dials; as in the preceding Examples.

Of

Of direct North and South Reclining and Inclining Plains, and how to draw Hour-Lines upon them.

ALL Plains that are not upright, do either recline from the Zenith, or incline to the Horizon; and of these sorts of Plains there are infinite Varieties; but we shall in this place only treat of such Plains as directly behold either the East, West, North or South-points of the Horizon, and recline from the Zenith, and incline to the Horizon; and these are called direct reclining or inclining Plains: And all the difficulty that is in the making of these Dials is,

How to find the height of the Pole or Stile above any direct North or South Reclining or Inclining Plain.

The manner how to find the Reclination and Inclination of any Plain is already taught. Wherefore,

If the Plain directly behold the South, and recline from the Zenith, then it is called a South-Reclining Plain. And,

To find the height of the Pole or Stile above such a Plain;

Consider,

1. If the Reclination of the Plain be less than the Complement of the Latitude, substract the Plains reclination from the Complement of the Latitude of the place, and the remainder shall be the height of the

Pole

Pole above the Plain, and the South-Pole is elevated as is in all upright South-plains.

2. If the Reclination of the Plain be greater than the Complement of the Latitude of the place, substract the Complement of the Latitude of the Place from the Reclination of the Plain, and the Remainer is the Elevation of the North Pole above the Plain.

3. If the Reclination of the Plain be equal to the Complement of the Latitude of the place, then doth the plain lie parallel to the Axis of the World, and neither Pole is elevated above it; but all the Hour-lines must be parallel one to the other, as in the East and West Dial; only this remember, that as in the East or West-Dials the Stile stands always upon the Hour-Line of 6; in these Recliners it must stand upon 12; for the 6 a Clock-Line in an East or West-Dial is the 12 a Clock Line in one of these Polar Dials.

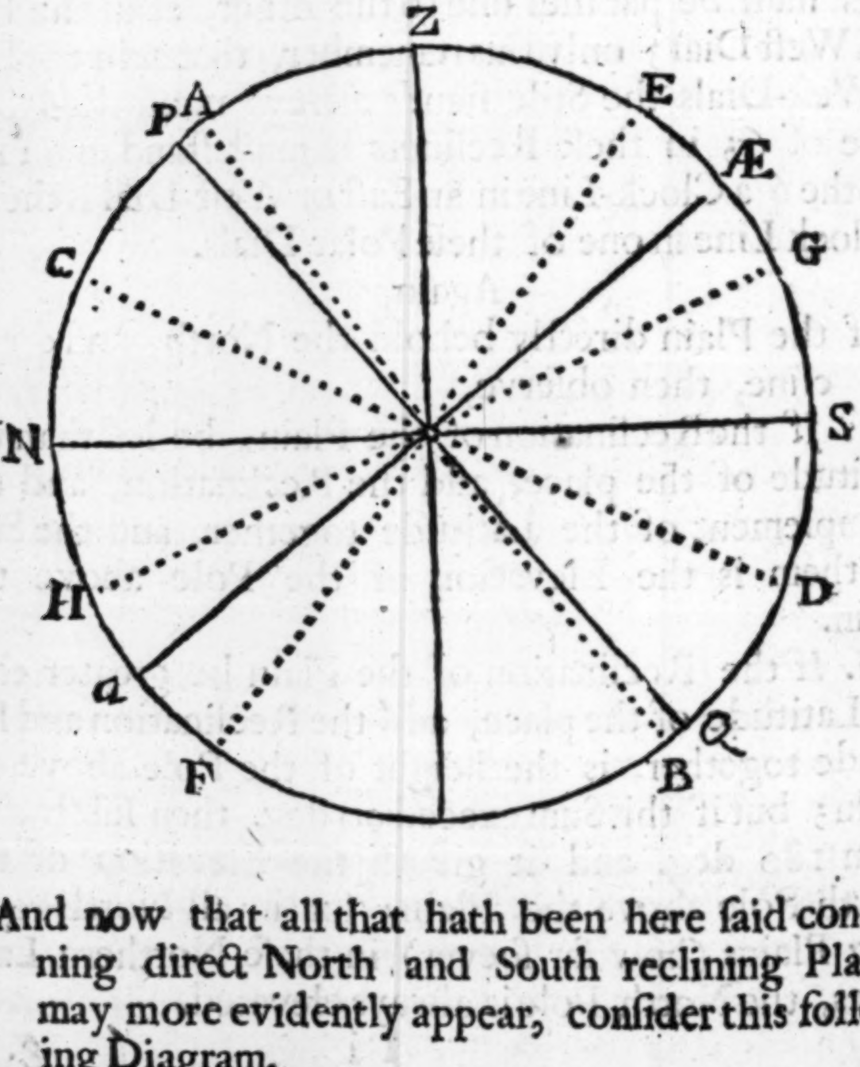
Again,

If the Plain directly behold the North, and do recline, then observe,

1. If the Reclination of the Plain, be less than the Latitude of the place, add the Reclination, and the Complement of the Latitude together, and the Sum of them is the Elevation of the Pole above the Plain.

2. If the Reclination of the Plain be greater than the Latitude of the place, add the Reclination and Latitude together, is the height of the Pole above the Plain; but if this Sum exceed 90 deg. then substract it from 180 deg. and it giveth the Elevation of the North Pole above the Plain; for in all North-reclining Plains (how far soever) in these Northern Latitudes, the North Pole is always elevated.

3. If the Reclination of the Plain be equal to the Latitude of the Place, then the Plain lieth in the Plain of the Equinoctial, and the North Pole is elevated just 90 deg. So that a Circle being divided into 24 equal parts, and a ſtreight Pin or Wire ſet up in the Center, this Dial is finiſhed, and the upper face thereof will give the hour all that part of the year that the Sun hath North declination; and the inclining Plain (or under face thereof) will give the hour all the time that the Sun hath South declination.



And now that all that hath been here ſaid concerning direct North and South reclining Plains, may more evidently appear, conſider this following Diagram.

In

In which let N P Z Æ S represent the Meridian of the place.

N S the North and South points of the Horizon.

Z the Zenith of the place.

P the North Pole, elevated above N, the North part of the Horizon 51 deg. 30 min.

Q the South Pole, depressed under S the South part of the Horizon, as much as P is elevated above the North.

P Q the Axis of the World.

Æ the Equinoctial elevated above S the South part of the Horizon 38 deg. 30 min. equal to the Complement of the Latitude, and depressed below N the North part of the Horizon as much.

A B } Two South reclining Plains.
C D }

E F } Two North declining Plains.
G H }

1. Now suppose the South reclining Plain A B, to recline 35 deg. which is less than Z P, 38 d. 30 min.

wherefore, Z A	35--00
taken from Z P	38--30
leaves P A	03--30.

For the elevation of the South Pole Q above the Plain A B.

2. Suppose the South reclining Plain CD, to recline from the Zenith 65 deg. which is more than ZP 38 d. 30 m.

		d. m.
Wherefore ZP	———	38--30
taken from ZC	———	65--00
leaves PC	———	26--30

For the elevation of the North Pole P above the South reclining Plain C D.

Again:

1. Suppose the North reclining Plain EF, reclining from Z, the Zenith, 35 d. less than ZÆ 51 d. 30 m.

		d. m.
PZ, the Complement of the Latitude	———	38--30
added to ZE, the Reclination	———	35--00
gives PE	———	73--30.

For the elevation of the North Pole P above the North reclining plain E F.

2. Suppose the reclining Plain GH, reclining from Z, the Zenith, 65 deg. greater than ZÆ, the Latitude

		d. m.
P Z the Complement of the Latitude	———	38--30
added to ZG the Reclination	———	65--00
gives GP	———	103--30.
which substracted from	———	180--00
leaves HP	———	76--30

The Elevation of the North Pole P, above the North reclining Plain G H.

For

For the drawing of Hour-Lines upon these South and North reclining Plains;

THere is no more trouble in the making of these Dials, than in making the full South, or Horizontal Dial, before taught.

For, when you have found the elevation of the Pole above the Plain, you must count that as the Latitude of your place, and so making an Horizontal Dial for that Latitude, your work is at an end. For this thing which is so obvious, Examples were superfluous; but when I have a little treated of East and West Recliners and Incliners, I will give you a sight of all the Varieties in one general Scheme.

Concerning East and West Reclining and Inclining Plains.

AN East or West reclining Plain in any Latitude, is no other, than an upright Plain declining so many degrees as is the Complement of the Reclination, in that Latitude that is equal to the Complement of the given Latitude; So,

	d.	m.		d.	m.
In the Lat. of	40	00	An East or West Plain Reclining	32	00
	51	03		35	00
	30	10		70	00

Is

	d.	m.		d.	m.
Is no other than	58	00		50	00
an Erect Plain	55	00	In the Lat. of	38	30
declining	20	00		59	50

Only the placing of the Dial is otherwise; for whereas in all upright Plains, whether direct or declining, the Meridian or hour-Line of 12, is perpendicular to the Horizon; so in all East and West reclining and inclining Plains, the Meridian or hour-line of 12 lies always parallel to the Horizon: And the North Pole is always elevated above all East or West Recliners. And the South Pole above the Incliners, opposite to them.

How to draw Hour-Lines upon an East or West Reclining Plain.

Let it be required to draw the Hour-lines upon an East Plain, reclining from the Zenith 35 deg. in the Latitude of 51 deg. 30 min. This is no other than an upright Plain declining 55 deg. in the Latitude of 38 deg. 30 min. Wherefore, if you make an upright South Dial declining 35 deg. for the Latitude of 38 d. 38 m. the Meridian Line being turned about till it lie in the Horizontal Line, it shall be your East declining Plain desired.

Objection.

But it may be here objected, that, How shall I make

make a declining Dial for the Latitude of 38 deg. when as I have no such Azimuth-Scale upon my Instrument.

Answer.

It is true, there is no such Scale; but such a one may easily be put on, or be supplied by the Line of the Suns Altitude, or Line of general Signs: And therefore I will in this place, for variety, shew you how you may by that Line of Signs, and the Line of Latitudes only, find all the Requisites, as Deflection, Height of the Stile, *&c.* belonging to a declining Dial in any Latitude, and so consequently in this Latitude of 38 d. 30 m.

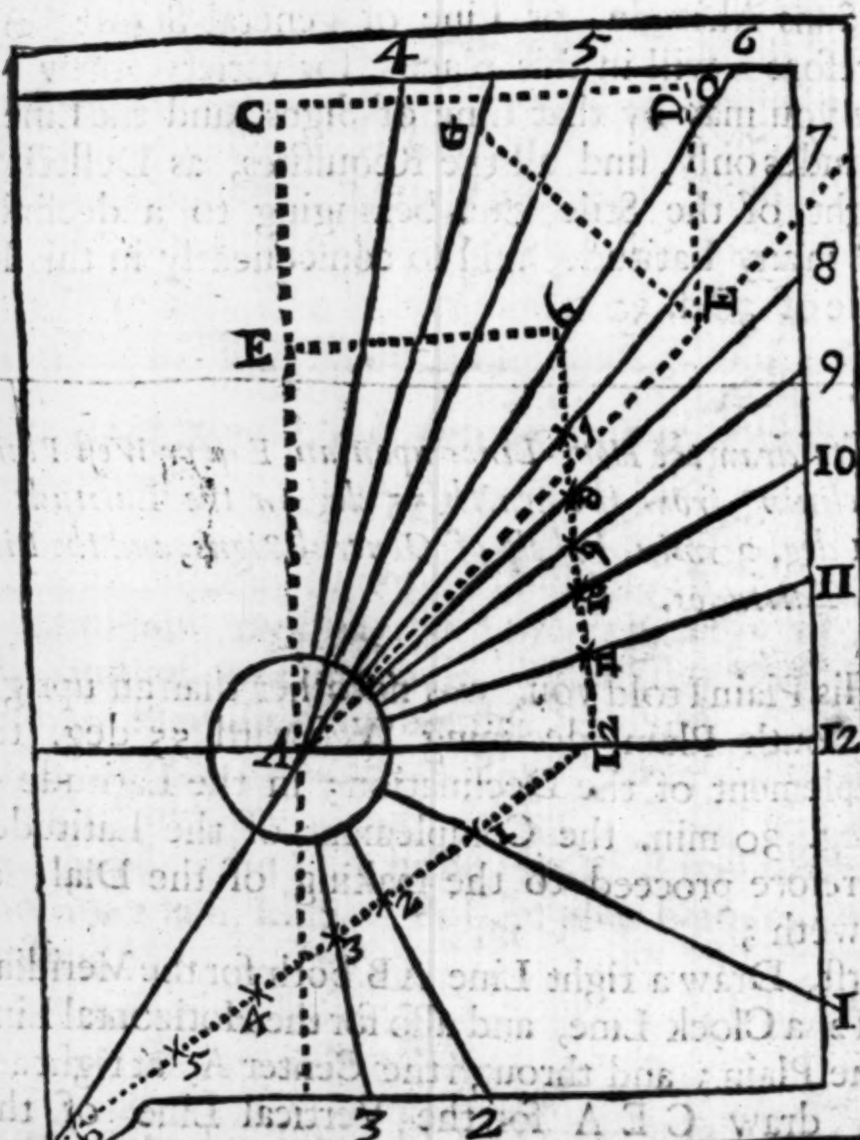
How to draw the Hour-Lines upon an East or West Plain, reclining from the Zenith 55 deg. in the Latitude of 51 deg. 30 min. by help of General Signs, and the Line of Latitudes.

THis Plain I told you, was no other than an upright South Plain, declining Westward 55 deg. the Complement of the Declination; in the Latitude of 38 deg. 30 min. the Complement of the Latitude: Wherefore proceed to the making of the Dial, as followeth;

First, Draw a right Line AB both for the Meridian and 12 a Clock Line, and also for the Horizontal Line of the Plain; and through the Center A, at right angles, draw CEA for the Vertical Line of the Plain.

Now

Now repair to your Instrument, and take 38 d. 30 m. out of the Latitude Line, and set that distance upon the Meridian from A to B. Also take the Complement of the same Latitude, *viz.* 51 d. 30 m. out of the same Latitude-Scale, and set it from A to C, in the Vertical Line, and draw C D equal and parallel to A B, and B D equal and parallel to A C.



Now because there is no Azimuth-Scale upon your Instrument for the Latitude of 38 deg. 30 min. we must therefore perform all our work by the Line of the Suns Altitude, which is the General Line of Signs, and that is to be effected in this manner; not only for this Latitude of 38 d. 30 min. but for any other that is not upon your Instrument. Therefore,

Secondly, Out of this Line of Signs, take 51 d. 30 m. the Complement of the Latitude for which you are to make your Dial; and setting one foot of this extent in the Sign of 90 deg. Bring the Thred to the nearest distance, and there keep it; for it is fitted for your whole work, without any alteration. Secondly

Thirdly, Out of the Line of Signs at the nearest distance to the Thred, take the Sign-Complement of the Reclination of the Plain, *viz.* 55 deg. and set that distance from B to F, and from C to O; and draw the Lines A O for the hour-line at 6, and A F, for the Substilar Line. Thirdly

Fourthly, Out of the same Line of Signes (the Thred being not moved from its place) take the Sign of the Plains Reclination, *viz.* 35 deg. by the nearest distance to the Thred, and set that distance from A to 12 upon the Meridian; and from F to G, making F G perpendicular to A F; and draw the Line A G for the Stile of the Dial. Fourthly

Fifthly, From the Line of Signs, at the nearest distance to the Thred, take 51 deg. 30 min. the Complement of the Latitude of the place; and set that distance from A to E, and through E draw a Line parallel to A B, till it cut the Hour-Line of Six in the point 6. And taking in your Compasses the distance Fifthly

from A to 6, set the same distance from A to 6 on the other side of the Center of the Dial; and draw the Lines 6, 12, and 6, 12.

Lastly, Take one of the Lines 6, 12, in your Compasses, and carrying it to your Line of three hours, deal with it as in the other Dials before; do the like with the other Line 6, 12: And having found the several points 11, 10, 9, 8, 7, in one Line, and 1, 2, 3, 4, 5 in the other, through them draw right Lines, and they shall be the true hour-lines of

A direct East Plain reclining 35 deg. in the Latitude of 51 d. 30 m.

Or,

Of an upright South Plain, declining Eastward 55 deg. in the Latitude of 38 d. 30 m.

Now in the making of this one East Reclining Dial, you have made 4 Dials, *viz.*

An { East / West } Reclining 35 d. 0 m.
And an
{ East / West } Inclining 35 d. 0 m.

By turning of the Paper, and by drawing of the Lines through the Center, as hath been already shewed in the upright Decliners.

And now note, that with these sorts of Dials already treated of, divers Regular Bodies cut in Wood or Stone, may be furnished with Dials: But before I proceed farther in this Discourse, I

will give you a sight of two North and South Reclining Plains, reclining 35 deg. in the Latitude of 51 d. 30 m. the making whereof, is no other than to make an Horizontal or Vertical Dial for such a Latitude.

I. Example of a North Plain Reclining from the Zenith 35 deg.

	d. m.
Add 35 d. the Reclination	35--00
To 38 d. 30 m. the compl. of Latitude	38--30
The height of the Stile is	73--30

Wherefore an Horizontal Dial made for the Latitude of 73 d. 30 m. is a North reclining Dial 35 d. in the Latitude of 51 d. 30 m.

II. Example of a South reclining Plain 35 d. in the Latitude of 51 d. 30 m.

	d. m.
Substract 35 d. the Reclination	35--00
From 38 d. 30 m. the compl. of Latititude	38--30
There remains the height of the Stile	03--30

So that an Horizontal Dial made for the Latitude of 3 d. 35 m. will become a South Dial reclining 35 d. in the Latitude of 51 d. 30 m.

And,

A North-Plain reclining 35 d. } is also { A South incl. 35.
A South-Plain reclining 35 d. } { A North incl. 35.

Kk 2 And

And so of any other Reclination; for in all cases, having made one reclining Dial, you have also made his opposite inclining: Only if the North Pole be elevated over the one, the South is over the other; and the contrary. And now I will give you a sight of these Recliners in Figure, omitting any farther Discourse concerning them in this place.

In the North reclining Plain, A D is the Sign of 90 d.
AB and A C the Sign of 73 d. 30 m.
B D and C D divided from the Line of 3 hours, gives the hour-points.

In the South reclining Plain,
G 12. is the Meridian Line.
G H. the true Stile.
E F. the augmented Stile.
I K, and L M. the two Tangent Lines.

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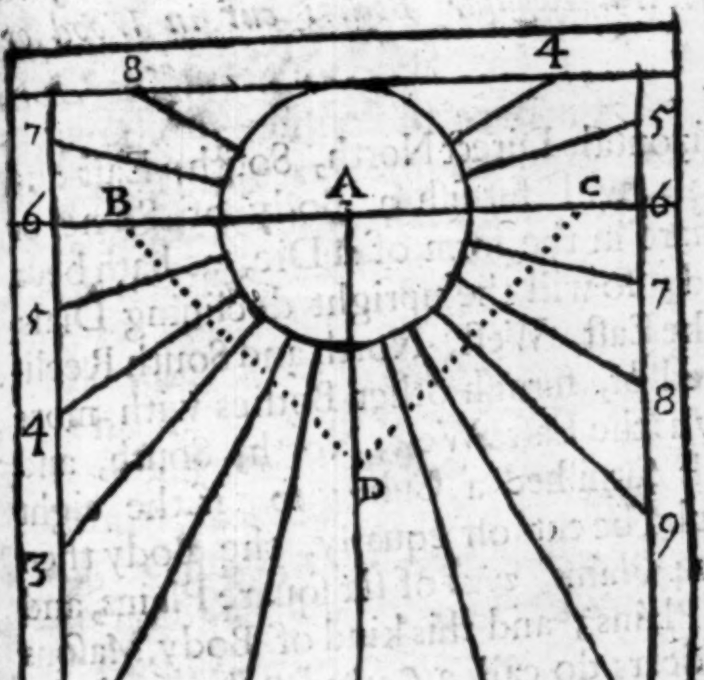

North reclining 35 deg Lat.51 d.30m.

South reclining 35 deg in Lat. 51 de. 30 m.

How

How the forementioned Dials may be applied to the furnishing of several Regular Bodies cut in Wood or Stone.

AS the Horizontal, Direct North, South, East and West Dials will furnish a Body of Stone or Wood, cut square in the form of a Die, as hath been before intimated; so will the upright declining Dials, together with the East, West, North and South Recliners, last treated of, furnish other Bodies with more variety: Now as the East, West, North, South, and Horizontal Dials furnished a Cube; so, if the eight Corners of a Cube be cut off equally, the Body then will consist of 14 Plains, *viz.* of six square Plains, and eight triangular Plains; and this kind of Body Masons and other Artificers do call a *Canted Cube*; and the declining and reclining Dials last treated of, will furnish such a Body of Stone or Wood.

As for Example,

If you set a Canted Cube upon one of the Squares, and turn one of the Angular points to behold the South; then will the Square which is on your right hand, be an upright South Plain, declining Eastward 45 deg. and the Square opposite to it, will be a North, declining West as many degrees.

Likewise, The upright Square which is on your left hand, will be an upright South-Plain declining 45 deg. Westward, and its opposite Square a North, declining Eastward as much.

Again,

Again, The uppermoſt triangular Plain which you ſet to behold the South, will be a South reclining plain 35 deg. and the undermoſt Triangle, oppoſite to it, on the North ſide, will be a North Incliner 35 deg. alſo; one Dial ſerving for both.

Alſo the uppermoſt triangular plain beholding the North, will be a North reclining Plain 35 deg. and the undermoſt triangular Plain beholding the South, will be a South inclining Plain 35 deg.; one Dial ſerving for both theſe.

Likewiſe, The uppermoſt triangular Plain on the right hand, is an Eaſt Plain, reclining 35 deg. and the undermoſt an Eaſt Plain inclining as much. That uppermoſt triangular Plain on your left hand, is a Weſt Plain, reclining 35 deg. and the undermoſt triangular Plain is a Weſt inclining as much. And one Dial maketh all theſe four.

And from hence you may gather that four Dials (beſides the Horizontal) will furniſh this Body of 14 Plains with Dials: For,

1. The upright Dial declining 45 deg. will ſupply

The { South declining { Eaſt, Weſt } ; North declining { Eaſt, Weſt } } 4

2. The

2. The South Recliner 35 deg. will ſupply

The { South Recliner
North Incliner } 2.

3. The North Recliner 35 deg. will ſupply

The { South Recliner
North Incliner } 2.

4. The Eaſt Recliner 35 deg. will ſupply

The { { Eaſt
Weſt } Recliner
{ Eaſt
Weſt } Incliner } 4.

5. The Horizontal ———————————— 1.

6. The Baſe on which the Body ſtandeth —— 1.

In all 14.

And thus you ſee that theſe ſorts of Dials will furniſh ſeveral regular Bodies; and divers Bodies may be formed to them; and this laſt Body is one that is as uſually cut in Wood or Stone as any.

There

There are indeed the five Platonick or regular Bodies; *viz.*

The	1. Cube ————	Consisting of	6. Square	Plains.
	2. Tetraedron----		4. Triangular	
	3. Octoedron-----		8. Triangular	
	4. Dodecaedron-		12. Pentagonal	
	5. Icosaedron——-		20 Triangular	

All which (except the Cube) consist for the most part of declining-reclining Plains. These Bodies are usually cut in Stone, and the manner how to form them is well known to the more Ingenious Masons; and seeing they are so common, and that we have nothing in this Treatise concerning declining-reclining Plains, I will in this place only give you all the Requisites (as height of Stile, *&c.*) belonging to all the Dials appertaining to these five Regular Bodies, together with Tables of the Hour-distances of each hour from the Sub-stile; so that having one of these Bodies in Wood or Stone, you may furnish it with Dials, by help of a Line of Cords. The Requisites and Tables which I shall here add, are those of Mr. *Wells's* in his *Sciographia*; from whom I in some Measure transcribe them: And,

I. *Of the CUBE.*

A Cube is a solid Body, comprehended under six equal Geometrical Squares.

This Body is capable of five ordinary Dials, the sixth Square being the Base to stand upon; wherefore if

you set any one side to behold the South, the Square on the right hand shall behold the East ; that on your left hand, the West ; and that opposite, or behind that which beholdeth the South, shall look towards the North : So that the five ordinary Dials, *viz. Horizontal, East, West, North* and *South* Dials will furnish this Body with Dials, as hath been before hinted ; it being situate in this Position.

But, if you place one of the Angles of the Cube to behold the South, then will the Square that is on your right hand be capable of a South-Dial declining Eastward 45 deg. the Square on the left hand, of a South-declining Westward 45 deg. the Square opposite to that Square which declineth from the South Eastward, will be capable of a North Dial, declining westward 45 deg. and that opposite to the South declining West, will be capable of a North declining Dial Eastw. 45 deg. And so by setting the four Angles to behold the East, West, North and South-Points, the Body will be furnished with 5 Dials of another kind differing from the former ; in every of which four Dials declining 45 deg.

			d. m.
The	Distance of the Sub-stile from the Meridian, is	——	29--20
	Height of the Stile is	——	26--06

And the distance of each hour-Line from the Substile, will be such as is expressed in this Table Following. So that by the help of a Line of Cords only, you may draw your Dials, and finish your Body.

A Table of the Hour-Distances for an upright South-Dial, declining 45 deg. either East or West.

Hours in the Decliner. East	Hours in the Decliner. West	Hour-Distances from the Substile. d.	m.
IX	III	3	4
X	II	10	3
XI	I	18	18
XII		29	20
I	XI	45	57
II	X	72	11
The		Substile.	
III	IX	3	34
IIII	VIII	10	36
V	VII	19	00
VI		30	19
VII	IV	47	30
VIII	IIII	74	31

II. *Of the* TETRAEDRON.

THe *Tetraedron* is a ſolid Body comprehended under four equal equilateral Triangles: So is this body capable of three Dials, reclining 19 d. 28 m. and a Baſis whereon to ſtand. Now if one of the Angles be ſet to behold the South, the Plain oppoſite to that Angle, will be a direct North-Plain, reclining 19 d. 28 m.

	d.	m.
North reclining	19	28
Compl. Latitude Add	38	30
Height of the Stile	57	58

The Hour-diſtances from the Meridian.

Hours from the Meridian.		Hour-diſtances on the Plain.		Hours from the Meridian.		Hour-Diſtances on the Plain.	
12		00	00	-			
-		6	22	8	4	47	50
11	1	12	48	-		55	44
-		19	21	7	5	63	57
10	2	26	4	-		72	27
-		33	2	6	6	81	10
9	3	40	17			90	00

The

The other two are South Plains, reclining 19 deg. 28 min. and declining, the one Eastward, and the other Westward, 60 deg.

In both which Dials.

		d.	m.
The	Distance of the Meridian from the Horizon is	60	00
	Distance of the Sub-stile from the Meridian	2	37
	Arch of the Meridian between the Plain and the Zenith	35	16
	Height of the Pole above the Plain	1	51
	Inclination of Merid.	54	47

And therefore the Sub-stile falleth between the hours of 8 and 9 in the Morning in the East decliner; and between the hours of 3 and 4 in the Afternoon in the West Dial; and the hour, and half-hour-distances are as in the following Table: One Dial serving for both Plains.

The

The Hour-distances for the two South-declining-reclining Dials.

Hours from the Substile.		Hour-dist. from the Sub-stile.		Hours from the Substile.		Hour-dist. from the Substile.	
Hours.		d	m.	Hours.		h.	m.
-		0	4	8	4	0	10
9	3	0	19	-		0	25
-		0	35	7	5	0	41
10	2	0	52	-		0	58
-		1	10	6	6	1	18
11	1	1	32	-		1	42
-		2	0	5	7	2	13
12	12	2	37	-		2	55
-		3	31	4	8	4	0
1	11	5	0	-		5	56
-		8	8	3	9	10	36
2	10	19	26	-		29	2

III.

III. *Of the* OCTOEDRON.

THe *Octoedron* is a ſolid Body comprehended under eight equal equilateral Triangles; ſo that the Body will be capable of 7 Dials beſides the Baſis on which it ſtandeth. Then if you ſet one of the Angles to behold the South, the inclining Plain under that Angle, ſhall be a South Plain inclining 19 d. 28 m. and the oppoſite Triangle ſhall be a North reclining as much; and the declining and reclining Plains, as alſo the declining inclining Plains will alſo decline 60 deg. and recline and incline 19 d. 28 m. as did the Recliners in the *Tetraedron*; ſo that the Dials of that Body will ſerve to furniſh this Body with Dials alſo; the inclining Plains being deduced from the Recliners, as an Eaſt Decliner is made to ſupply a Weſt Decliner. And this may be made evidently to appear, by joyning the reclining ſide of the *Tetraedron*, to the inclining ſide of the *Octoedron*. The Dials therefore for this Body being the ſame as for the other, the former Tables will ſerve, and ſo nothing more need be ſaid concerning it.

Of the DODECAEDRON.

THe *Dodecaedron* is a Solid Body comprehended under Twelve equal equilateral and equiangled *Pentagons*. This Body is capable of eleven Dials, beſides the Baſis upon which it ſtandeth. Wherefore, if you ſet any of the Angles of the Horizontal Plain to behold the South, rhe inclining Plain under that Angle,

Angle, ſhall be a direct South Plain, inclining 26 d. 34 m. and its oppoſite ſhall be a North reclining as much.

Moreover, the two reclining Plains, whoſe ſides do contain the Angle that beholds the South, ſhall be the one a South declining Eaſtward, and the other a South declining Weſtward 36 deg. and either of them declining 26 deg. 34 min. And the two Plains oppoſite to them ſhall be, the one a North declining Eaſt, and the other a North Declining Weſt 36 deg. and reclining alſo 26 deg. 34 m. ſo that one Dial ſerveth for all four.

Again, the two reclining Plains which lie on either ſide of the direct North Recliner, do recliue equal thereto, *viz.* 26 deg. 34 m. and decline from the North, the one towards the Eaſt, and the other towards the Weſt 72 deg. And the two Plains oppoſite to them, inclining alſo 26 deg. 24 min. do decline alſo from the South, the one towards the Eaſt, the other towards the Weſt 72 deg. And one Dial ſerveth for all theſe four alſo. So that three Dials, beſides the Horizontal, will ſupply all the Plains of this Body. The Requiſites with the Tables of their Hour-diſtances here follow.

	d.	m.
1. The North-Recliner And The South-Incliner,	26	34
Compl. added	38	30
The height of the Stile	65	4

The

The Hour-distances for the North Recliner, and the South Incliner.

Hours from the Meridian.		Hour-distance from the Merid.			Hours from the Meridian.		Hour-Distanc. from the Merid.		
12		00	-	00	-				
-		6	-	48	8	4	49	-	45
11	1	13	-	39	-		57	-	30
-		20	-	35	7	5	65	-	00
10	2	27	-	38	-		73	-	32
-		34	-	49	6	6	81	-	44
9	3	42	-	12			90	-	00

The two North Recliners, and their opposite South Incliners inclining 72 deg. have the same Dial serving for all forms, changing of the position of the Substile and the naming of the hours, as is before directed, the Requisites whereof, with the Table of Hour-distances follow.

	d. m.
North Reclining, or South inclining—	26-34
Declining East and West ——	72-00

		d. m.
The	Distance of the Meridian and the Horizon	36--00
	Arch of the Meridian between the Plain and the Zenith	58--17
	Height of the stile	31--28
	Distance of the Substile from the Meridian	82-- 5
	Inclination of Merid.	85--51

The Hour-Distances for the North reclining, and the South inclining Plains, declining 36 deg.

Hours from the Substile.		Hour-dist. from the Sub-stile.		Hours from the Substile.		Hour-dist. from the Substile.	
Hours.		d	m.	Hours.		d.	m.
6	6	2	50	5	7	1	42
-		6	9	-		5	43
7	5	10	17	4	8	9	49
-		14	41	-		14	12
8	4	19	30	3	9	18	58
-		24	55	-		24	18
9	3	31	7	2	10	30	25
-		38	26	-		37	35
10	2	47	9	1	11	46	8
-		57	35	-		56	22
11	1	69	51	12	12	68	26
-		83	37	-		82	5

The

The two South Recliners, and their oppoſite Incliners, declining 36 deg. 0 min. have alſo the ſame Dial ſerving for all four, obſerving the former Cautions, *viz.* changing of the Hours, and turning the Subſtile to the contrary Coaſt. The Requiſites whereunto follow, and alſo the Table of the Hour-Diſtances.

	d.	m.
South Reclining, or, North Inclining	26	34
Declining Eaſt and Weſt—	36	00

		d.	m.
1.	The Diſtance of the Meridian from the Horizon.	72	00
2.	The Arch of the Meridian between the Plain and the Zenith	31	43
3.	The Height of the Stile	05	44
4.	The Diſtance of the Sub-ſtile from the Meridian	03	34
5.	The Inclination of Meridians.	31	54

The Hour-Distances for the South reclining, and the North inclining Plains, declining 36 deg.

Hours from the Substile.		Hour-Distances from the Substile.		Hours from the Substile.		Hour-Distances from the Substile.	
Hours.		d.	m.	Hours.		d.	m.
10	2	0	11		-	0	34
	-	0	57	9	3	1	20
11	1	1	44		-	2	9
	-	2	36	8	4	3	3
12	12	3	34		-	4	6
	-	4	41	7	5	5	21
1	11	6	6		-	6	56
	-	7	57	6	6	9	7
2	10	10	36		-	12	26
	-	14	53	5	7	18	13
3	9	23	15		-	31	9
	-	45	32	4	8	71	42

The

V. *Of the* ICOSAEDRON.

THe *Icosaedron* is a solid Body, comprehended under twenty equal equilateral Triangles, and therefore is capable to receive 19 Dials, besides the Plain or Basis upon which the Body standeth. Then if you set any of the Angles of the Horizontal Plain to behold the South, the rest of the Plains will have such reclination, inclination and declination as is hereunder expressed.

1. Horizontal ——— 1
2. North reclining and South inclining 48 d. 11. m. 2
3. South reclining, North inclining 48 d. 11 m. and declining East and West *60* deg. ——— 4
4. South reclining and North inclining 19 d. 28 m. declining East and West 24 d. 14 m. ——— 4
5. North reclining and South inclining 19 d. 28 m. and declining East and West 24 d. 14 m. ——— 5
6. North reclining, and South inclining 19 d. 28 m. and declining East and West 37 d. 44 m. ——— 4

In all ——— 19

The Requisites, with the Tables of the Hour-Distances proper to all which Plains here follow in their Order.

	d.	m.
North reclining ———	48	11
Add ———	38	30
Height of the Stile ———	86	41

The

The Hour-distances for the North Reclining, and the South Inclining Plains.

Hours from the Meridian.	Hour-distance from the Merid.		Hours from the Meridian.	Hour-Distanc. from the Merid.	
Hours.	d.	m.	Hours.	d.	m.
12	00	00	3 9	44	57
-	7	29	-	52	27
1 11	14	50	4 8	59	57
-	22	28	-	67	28
2 10	29	57	5 7	74	59
-	37	27	-	82	29
3 9	44	57	6 6	90	00

1. The two South Recliners, and their opposite Incliners 48 d. 11 m. and declining 60 deg. have the same Dial serving for all four, observing the former Cautions, the Requisites and Table of Hour-distances thereunto belonging, follow.

		d.	m.
1.	The Arch of the Plain between the Meridian and Horizon	37	46
2.	The Arch of the Merid. between the Plain and Zenith.	65	54
3.	The Height of the Pole or Stile.	22	6
4.	The distance of the Substile and the Meridian.	16	41
5.	The Inclination of Meridians.	38	31

The

The Table of the Hour-Distances.

Hours from the Substile.		Hour-Distances from the Substile.		Hours from the Substile		Hour-Distances from the Substile.	
Hours.		d.	m.	Hours		d.	m.
	-	0	24		-	2	26
10	2	3	14	9	3	5	20
	-	6	11		-	8	25
11	1	9	19	8	4	11	45
	-	12	46		-	15	32
12	12	16	42	7	5	19	56
	-	21	19		-	25	17
1	11	27	0	6	6	32	0
	-	34	13		-	40	48
2	10	43	45	5	7	52	36
	-	56	34		-	68	13
3	9	73	16	4	8	57	12

The two South reclining and North inclining 19 d. 28 m. and declining 24 d. 14 m. have the ſame Dial ſerving for all four, the Requiſites and Table of Hour-Diſtances follow.

1. The Arch of the Plain between the Merid. and Horizon.	82	14
2. The Arch of the Merid. between the Plain and the Zenith.	20	54
3. The Height of the Pole or Stile above the Plain.	16	22
4. The diſtance of the Subſtile from the Merid.	6	27
5. The Inclination of Meridians.	21	50

The

The Table of the Hour-Distances.

Hours from the Substile.		Hour-Distances from the Substile.		Hours from the Substile		Hour-Distances from the Substile.	
Hours.		d.	m.	Hours		d.	m.
11	1	1	56	-		0	11
-		4	7	10	2	2	19
12	12	6	27	-		4	32
-		9	0	9	3	6	53
1	11	11	55	-		9	29
-		15	24	8	4	12	30
2	10	19	44	-		16	6
-		25	26	7	5	20	37
3	9	33	22	-		26	38
-		45	9	6	6	35	8
4	8	63	1	-		47	49
-		87	38	5	7	66	58

The two middle North Plains reclining 19 d. 28 m. and their opposite South inclining, and declining also 82 d. 14 m. have the same Dial serving for all four, whose Requisites and Table of Hour-Distances follow.

1. The Arch of the Plain between the Meridian and Horizon 22 14
2. The Arch of the Merid. between the Plain and Zenith. 69 6
3. The Height of the Pole or Stile above the Plain. 19 53
4. The distance of the Substile from the Meridian. 71 18
5. The Inclination of Meridians. 83 25

The

The Table of Hour Diſtances.

Hours from the Subſtile.		Hour-Diſtances from the Subſtile.		Hours from the Subſtile.		Hour-Diſtances from the Subſtile.	
Hours.		d.	m.	Hours.		d.	m.
-		0	19	6	6	2	15
5	7	2	53	-		4	53
-		5	33	7	5	7	40
4	8	8	23	-		10	43
-		11	31	8	4	14	10
3	9	15	6	-		18	14
-		19	21	9	3	23	13
2	10	24	38	-		29	35
-		31	38	10	2	38	8
1	11	40	42	-		50	1
-		53	37	11	1	66	26
12	12	71	17	-		87	17

The other two North Recliners 19 d.28 m.and their oppoſite Incliners do decline 37 deg.46 min. One Dial ſerves all four, whoſe Requiſites and Hour-diſtances follow.

1. The Arch of the Plain between the Meridian and Horizon 75 1
2, The Arch of the Merid. between the Plain and Zenith. 24 6
3. The Height of the Pole or Stile above the Plain. 46 26
4. The diſtance of the Subſtile from the Meridian. 48 2
5. The Inclination of Meridians. 56 54

The Table of the Hour-Distances.

Hours from the Subſtile.		Hour-diſt. from the Subſtile.		Hours from the Subſtile.		Hour-diſt. from the Sub-ſtile.	
Hours.		d.	m.	Hours.		d	m.
-		3	12	8	4	2	14
9	3	8	41	-		7	43
-		14	19	7	5	13	19
10	2	20	12	-		19	9
-		26	24	6	6	25	17
11	1	33	2	-		31	50
-		40	13	5	7	38	55
12	12	48	2	-		46	37
-		56	32	4	8	55	0
1	11	65	44	-		64	4
-		75	32	3	9	73	46
2	10	85	44	-		83	55

And thus have I ſhewed, how you may furniſh theſe five Regular Bodies with Dials; as alſo the Canted Cube, after a moſt artificial way: But in regard that many times you may light of ſome of theſe Bodies ready cut, yet ſomewhat irregular, ſo that if you ſhould draw Dials on them, exactly following the true Rules of Art, the Dials (poſſibly) may not ſo exactly agree one with another as is deſired; therefore a more Mechanick way may be uſed to bring that Artifice about; and that is this:

When you would draw Dials upon any of theſe (or other

other Bodies) first be sure to draw the Horizontal and Vertical Lines of each Plain very exactly; then set off the Arches of the Plains between the Meridians and Horizons in their true positions and situations; and from thence the Substilar distances, the right way also. Then upon your Substilar Lines erect your Stiles at their true Angles, and be sure that the ends of your Stiles do always respect the true Poles of the World, which you may partly discern; for if there be an hundred or more Dials upon one Stone, the Stiles of all of them must respect both the Poles, and be all of them parallel one to another; and be sure also to erect all your Stiles perpendicular to your Dial-Plains. Having proceeded thus far with all the Dials on your Body, of what form soever (either regular or irregular) you may proceed to the pricking on of the Hour-points (which I would advise you to do, to prevent gross Mistakes) but not to draw the Hour-Lines out till you have made some trial in the Sun: For having made your Horizontal Dial true, if you bring your Body into the Sun-shine, and turn it about till the shadow of the Stile of the Horizontal Dial fall upon any desired Hour, then will the shadow of all the Stiles upon the several Plains (on which the Sun at that time shineth) shew that same Hour on those several Plains; as if you hold or turn the Body so that the Shadow of the Stile of the Horizontal Dial shall fall upon 10 of the Clock, then will the Shadows of the Stiles of the other Plains give the true place of 10 a Clock upon their respective Plains, and so at any other hour; and in this case it is not absolutely necessary, neither that the Horizontal Dial (during this work) should lie directly Horizontal;

The Table of the Hour-Distances.

Hours from the Subſtile.		Hour-diſt. from the Subſtile.		Hours from the Subſtile.		Hour-diſt. from the Sub-ſtile.	
Hours.		d.	m.	Hours.		d	m.
-		3	12	8	4	2	14
9	3	8	41	-		7	43
-		14	19	7	5	13	19
10	2	20	12	-		19	9
-		26	24	6	6	25	17
11	1	33	2	-		31	50
-		40	13	5	7	38	55
12	12	48	2	-		46	37
-		56	32	4	8	55	0
1	11	65	44	-		64	4
-		75	32	3	9	73	46
2	10	85	44	-		83	55

And thus have I ſhewed, how you may furniſh theſe five Regular Bodies with Dials; as alſo the Canted Cube, after a moſt artificial way: But in regard that many times you may light of ſome of theſe Bodies ready cut, yet ſomewhat irregular, ſo that if you ſhould draw Dials on them, exactly following the true Rules of Art, the Dials (poſſibly) may not ſo exactly agree one with another as is deſired; therefore a more Mechanick way may be uſed to bring that Artifice about; and that is this:

When you would draw Dials upon any of theſe (or other

other Bodies) first be sure to draw the Horizontal and Vertical Lines of each Plain very exactly; then set off the Arches of the Plains between the Meridians and Horizons in their true positions and situations; and from thence the Substilar distances, the right way also. Then upon your Substilar Lines erect your Stiles at their true Angles, and be sure that the ends of your Stiles do always respect the true Poles of the World, which you may partly discern; for if there be an hundred or more Dials upon one Stone, the Stiles of all of them must respect both the Poles, and be all of them parallel one to another; and be sure also to erect all your Stiles perpendicular to your Dial-Plains. Having proceeded thus far with all the Dials on your Body, of what form soever (either regular or irregular) you may proceed to the pricking on of the Hour-points (which I would advise you to do, to prevent gross Mistakes) but not to draw the Hour-Lines out till you have made some trial in the Sun: For having made your Horizontal Dial true, if you bring your Body into the Sun-shine, and turn it about till the shadow of the Stile of the Horizontal Dial fall upon any desired Hour, then will the shadow of all the Stiles upon the several Plains (on which the Sun at that time shineth) shew that same Hour on those several Plains; as if you hold or turn the Body so that the Shadow of the Stile of the Horizontal Dial shall fall upon 10 of the Clock, then will the Shadows of the Stiles of the other Plains give the true place of 10 a Clock upon their respective Plains, and so at any other hour; and in this case it is not absolutely necessary, neither that the Horizontal Dial (during this work) should lie directly Horizontal;

but being turned about, or held in any position, it will effect the same thing: But of this Mechanical way, I shall say no more, it being so obvious; and so I shall conclude this Tract of Dialling.

Lawrence ffairclough Bear & ffountain in Lothbury 1680

The

The Uses of the Circles INSCRIBED In the Quadrantal part of the Back-side of the *INSTRUMENT.*

SECT. III.

THe Circles on the Back-side are 1. The *Equal Limb*, divided into 90 d. 2. A Circle of *Right Ascensions in Time*, viz. the whole Quadrant being divided into 24 equal parts or hours, and numbred from the Left hand towards the Right by 1, 2, 3, 4, *&c.* to 24. each hour containing 3 deg. 45 min. of the equal Limb.

3. A Circle of *right Ascensions in Degrees and Minutes*, the Quadrant being divided into 360 equal degrees; so that one degree of the equal Limb is equal to 4 d. of this Circle of right Ascensions, and this Circle is numbred from the right hand towards the left, by 10, 20, 30, *&c.* to 360.

4. *A Zodiack*, or *Ecliptick* rather, it having at every 30*th* deg. of the Circle of right Ascensions a Character of one of the Signes of the Zodiack; as, at the beginning, towards the right hand, is ♈; at 30 d. forward, is ♉; at 30 d. more forward, is ♊; so

at

at 180 d. and ♓ at 330 d. and 360 d. at the end next the left hand.

5. Is a Circle containing only the Characters of Stars, as * *, with References from them to their Names placed above.

6. The Sixth Circle contains the Names of those Stars, whose Characters are in the Circle below, inserted according to their right Ascensions.

7. In the Seventh Circle is set the Declination of those Stars; and,

8. In the Eighth Circle, their Magnitudes.

Prob. I.

How to find at what Hour any Star expressed in your Instrument (or any other whose right Ascension and Declination is known) cometh to the Meridian any Day in the Year.

TO perform this Probleme Arithmetically, this is the General Rule;

Substract the Suns right Ascension for the Day or Night proposed, from the right Ascension of the Star (adding to the Stars right Ascension 24 hours when Substraction cannot be made without it) and the difference (or remainer) is the time of the Stars being upon the Meridian; and if this Difference or Remainer be less than 12 hours, it shews the Time Afternoon, or that Night that the Star will be upon the Meridian; but if the

the difference exceed 12 *hours, then reject* 12 *hours, and the overplus is the hour the next Morning, that the Star will be upon the Meridian.*

But to work this upon the Instrument, this is the Rule;

Lay the Thred to the Stars right Ascension counted in the hours-Circle, from the left hand towards the right, and thereto (if you will) lay the Thred, then take in your Compasses the Distance from the beginning of the Circle, to the Complement of the Suns right Ascension; this distance applyed to the hour-Circle, shall reach from the Stars right ascension, to the time that the Star will be upon the Meridian.

Example 1.

Let it be required to find what hour the Bulls Eye *will be upon the Meridian, upon the* 23 *of* December.

	h.	m.
The right Ascension of the *Bulls Eye* is	4	16
The Suns right Ascension is 18 h. 53 m. its Complement	5	7

Take in your Compasses (from the beginning of the hour-Circle to 5 h. 7 m. (the Complement of the Suns right Ascension) then setting one foot of this Extent to the Thred, or at 4 h. 16 m. (the Stars right Ascension) the other point of the Compasses will fall upon 9 h. 23 m. at which time the Star will be upon the Meridian at night, because the point of the Compasses fell short of 12 a Clock.

Another

Another way to effect the same.

Take in your Compasses the distance between the Stars right Ascension (4 h. 16 m.) and the Suns right Ascension (18 h. 53 m.) set one foot of the Compasses at the beginning of the Hour-Circle, and the other foot will fall upon 2 h. 37 m. the Complement whereof is 9 h. 23 m. the time of the Stars coming to the South is before.

There are other ways to perform this work upon the Instrument; but the first is the best: Wherefore take another Example or two.

Example 2.

Let it be required to find at what hour the Great Dog *will be upon the Meridian upon the same day,* viz. *the 23. of* December.

	h.	m.
The right Ascension of the *Great Dog* is	6	30
The Complement of the Suns right Ascension that day is	5	7

Set one foot of the Compasses in the beginning of the hour-Circle, and extend the other to the Complement of the Suns right Ascension, (*viz.* 5 h. 7. m.) the same extent will reach from 6 h. 30 m. the Stars Ascension, to 11 h. 37 m. at which time the *Great Dog* will be upon the Meridian on the 23. of *December* at night, because the Compass-point fell short of 12 of the Clock.

Example

Example 3.

Upon the 21 *of* January, *I would know when the* Bulls Eye *will be upon the Meridian.*

	h.	m.
Bull's Eye right Aſcenſion————	4	16
Complement of the Suns right Aſcenſion is--	3	2

Set one foot at the beginning of the Circle of Hours, and extend the other to 4 h. 16 m. the ſame extent will reach from 3 h. 2 m. to 7 h. 18 m. At which time the *Bulls Eye* will be upon the Meridian at night.

Example 4.

Let it be required upon the ſame day to find when the Lions Tail *will be upon the Meridian.*

	h.	m.
The right Aſcenſion of the *Lions Tail* is——	11	30
Complement of the Suns right Aſcenſion is---	3	2

Set one foot of the Compaſſes in the beginning of the Hour-Circle, and extend the other to the right Aſcenſion of the *Lions Tail*, viz. 11 h. 30. m. the ſame extent will reach from the Complement of the Suns right Aſcenſion (*viz.* 3 h. 2 m.) to 2 h. 32 m. wherefore at 32 m. paſt 2 the next morning the *Lions Tail* will be upon the Meridian, becauſe the Compaſs-point fell beyond the middlemoſt 12*th.* hour in the Circle.

Example 5.

Let it be required to find at what time Fomahant *cometh to be upon the Meridian the ſame* 21 *of* January.

In this Example (becauſe that *Fomahant* hath greater right Aſcenſion than 12 hours, and ſo ſtandeth on the right hand of the 12, which is in the middle of the Hour-Circle) you muſt, therefore, take the diſtance from 12 in the middle of the Circle to *Fomahant*, his right Aſcenſion being 22 h. 38 m. from which abating 12 h. there remains 10 h. 38 m. and that the right Aſcenſion muſt be counted to be. Wherefore take the diſtance from 12 in the middle of the Circle, (or from the beginning of the hour-Circle as before) to 10 h. 38 m. the ſame extent will reach from 3 h. 2 m. the Complement of the Suns right Aſcention to 1 h. and 40 m. beyond 12 in the middle of the Circle, and therefore *Fomahant* cometh to the Meridian at 40 m. paſt 1 of the Clock.

Note, That the *Amplitude*, the *Aſcenſional Difference*, and conſequently the *Riſing* and *Setting* of the Stars, and alſo the Stars-hour from the Meridian, are all to be ſound by the Lines on the Quadrantal part of the foreſide of the Inſtrument, in all reſpects as the ſame things were found for the Sun: For the *declination* of the Stars, they are inſerted in the Inſtrument, each againſt its reſpective name; and their *right Aſcenſions* are alſo given by the applying of the Thred to the Star; wherefore we will now proceed.

Prob.

Prob. 2.

TO find all the forementioned Particulars, instancing in the *Bulls Eye*, upon the 23 Day of *December*.

And,

1. *The Declination North*	of this Star by this side of the Instrument, is	h. m. 15 4
2. *The right Ascension*		h. m. 4 16

But,

3. *To find its Amplitude*,

Lay the Thred to 15 d. 48 m. counted in the equal Limb, from the Line of the Suns Altitude (or Line of 60 d.) towards the right hand, because the Star hath North Declination. Then take with your Compasses the distance from *Aries* or *Libra* to the Thred, and applying that Distance to the *Azimuth-Scale* proper to your Latitude, from 90 d. the Compass-point will fall upon 25 d. 54 m. and such is the Amplitude of that Star.

Then,

4. *To find its Ascentional Difference*.

Lay the Thred to the Stars Declination, counted upon the Limb from the Line of 60 (as before) and the Thred will cut the hour-Scale proper to your Latitude,

 titude,

titude, at 1 h. 23 m. counted from 6 a Clock, and that is the Stars Aſcentional Difference.

And by the ſame application of the Thred, will be found

5, and 6. *The Stars hour at the time of his Riſing and Setting.*

For, the Thred will reſt upon 7 h. 23. m. on the hour-Scale, which is the Stars hour at the time of his Setting from Noon, or upon 4 h. 37 m. for the time of his Riſing after Midnight.

And from hence will follow,

I. *To find how long any Star continues above the Horizon:*

The Rule.

If the Star hath $\left\{\begin{array}{l}\text{North}\\\text{South}\end{array}\right\}$ Declination $\left\{\begin{array}{l}\text{Adde}\\\text{Subſtract}\end{array}\right.$ the Aſcentional Difference of the Star in time $\left\{\begin{array}{l}\text{To}\\\text{From}\end{array}\right\}$ 6 hours, and the $\left\{\begin{array}{l}\text{Sum}\\\text{Remainer}\end{array}\right.$ is half the time that the Star continues above the Horizon.

Example.

	h.	m.
The Aſcentional difference of the *Bulls Eye* is	1	23
To which add	6	00
The Sum is	7	23

The

The double whereof 14 h. 46. m. is the time that the Star continues above the Horizon in Latitude 51 d. 30 m. and this taken from 24 h. leaves 9 h. 14 m. for the Nocturnal Ark of that Star.

But to perform this upon your Instrument, this is

The Rule.

To the Ascentional Difference of Stars of

North	Declination counted	beyond	6. Set one
South		Short of	

foot of your Compasses upon the beginning of the hour-Circle, and extend the other foot to the Ascen-

tional difference of the Star counted	Beyond	6,
	Short of	

and double that Distance upon the Hour-Circle, so

shall the moveable point fall upon the	Diurnal	
	Nocturnal	

Ark, if you count all the hours from the beginning of the Circle.

Thus, if you set one foot of the Compasses upon the beginning of the hour-Circle, and extend the other to 1 h. 23 m. beyond 6, (*viz.* to 7 h. 23. m.) that distance doubled shall extend to 2 h. 46 m. beyond the middle 12 in the hour-Circle, that is 14 h. 46 m. from the beginning of the Circle, and that is the Diurnal Arch.——

And if you take the distance from the beginning of the Hour-Circle, to the 23 m. short of 6 (*viz.* to

4

4 h. 37 m.) that distance being doubled, shall extend to 9 h. 14 m. which is the Nocturnal Ark of that Star.

II. *To find the time of a Stars Rising and Setting.*

The Stars hour at his Rising or Setting is not the true hour of the Night; but it is the distance of time since the Star was last upon the Meridian, and here you are to observe, That if your Star have $\left\{\begin{array}{l}\text{North}\\\text{South}\end{array}\right\}$ Declination, the Stars hour at his Rising must be reckoned to be $\left\{\begin{array}{l}\text{before}\\\text{after}\end{array}\right\}$ Six of the Clock; and the time of its Setting $\left\{\begin{array}{l}\text{after}\\\text{before}\end{array}\right\}$ Six of the Clock. And from hence we may collect the true time of the Day or Night that the Star riseth or setteth. And to perform this Arithmetically, this is

The Rule.

Adde the Complement of the Suns right Ascension, the right ascension of the star, and the stars hour at the time of his Rising, the Sum of all three (casting away twelve hours as often as you can) *shall be the true hour of the stars Rising.*

Thus:	h.	m.
The Right Ascension of the *Bulls Eye* ——	4	16
The Compl. of the Suns right ascens. *Dec.* 23.	5	7

The

The Stars hour at his Rising by the foregoing	4	37
	14	00
Substract 12 hours	12	00
Rests	2	00

Which must (by the last) be 2 of the Clock in the Afternoon; and for that by the first *Prop.* the Star was upon the last Meridian, at 23 min. after 9 at night.

And for the time of this Stars Setting, the same course must be taken. Wherefore,

	h.	m.
The Right Ascension of the *Bulls Eye*	4	16
Complement of the Suns Right Ascension	5	7
The Stars hour at his Setting	7	23
The Sum	16	46
Substract 12 hours	12	00
Rests	4	46

So the true hour of the Stars setting will be found to be at 46 m. past 4 in the Morning.

To perform this by the Instrument:

Take in your Compasses the distance from the beginning of the Hour-circle, to 4 h. 37 min. (the Stars hour at the time of his Rising) Then set one foot to 4 h. 16 m. (the Stars right Ascension) setting it forward upon the Hour-Circle, and to that point of your Compasses which is next your right hand, bring the Thred, and there keep it; then take out of the hour-

Scale

Scale the diſtance from the beginning to 5 h. 7 m. the complement of the Suns right Aſcenſion, ſo ſhall that diſtance reach from the Thred forward, to 2 of the Clock in the Afternoon, for the hour of the Day, when that Star was riſing.

And, If you take in your Compaſſes 4 h. 16 m. and ſet that diſtance forward from 7 h. 23 m. and thereto bring the Thred 5 h. 7 m. being ſet from the Thred forward, the moveable point will fall upon 4 h. and 46 m. at which time in the morning the *Bulls Eye* will be ſetting.

Many more Propoſitions of this kind may be found by the Lines on the Quadrantal Part of the Inſtrument. As,

1. To find what Altitude any Star ſhall have, when he is at any horary diſtance from the Meridian; By the 11*th*. *Probl.*
2. To find what Altitude a Star ſhall have, being upon any known *Azimuth*; by the 12*th*. or 13*th*.
3. The Stars Altitude being taken, by the 7*th*. *Prob.* you may find
4. What *Azimuth* he is upon, by the 14*th*. *Probl.* And,
5. The Stars hour or horary diſtance from the Meridian, by the 15*th*.

And now I ſhall proceed to

Prob.

Prob. 3.

Having the Altitude of a known fixed Star, to find the true Hour of the night.

Let it be required to find the true hour of the night upon the 23. of *December*, the *Bulls Eye* being obſerved to have 6 degrees of Altitude.

1. *Find the Stars horary diſtance from the Meridian, which is the Stars hour by the 15th Probl. of the firſt Thred.*

Lay the Thred to the Stars declination, counted on the Limb from 60 d. And out of the Scale of the Suns Altitude or Line of Sines take 6 d. the Stars Altitude obſerved. With this diſtance ſet one foot of the Compaſſes upon the hour Scale, and thence move it along till the other being turned about do only touch the Thred, ſo ſhall the Compaſs point reſt upon 6 hours and 42 m. from the Meridian, and that is the Stars hour: Now

2. *To find from hence the true hour of the night.*

There are ſeveral wayes to do it, as Arithmetically thus,

Add the Complement of the ☉ Aſcenſion, the Stars R. Aſcenſion, and the Stars hour, all three together, the ſum of them caſting away 12 is the hour of the night South. Thus,

Bulls

	h.	m.
Bulls Eye horary diſtance from the Meridian —	6	42
Its R. Aſcenſion — — — —	4	16
Complement of Suns R. Aſcenſion — — —	5.	7
their Sum--- — - —	16	5
	12	0
12 Hours ſubſtracted, there remains — — — — the true hour of the night — - —	4	5

This by the Circle on the backſide of the Inſtrument is done more eaſie, and general, and for the doing of it in all Caſes this is

The Rule.

Set one foot of the Compaſſes in the complement of the Suns R. Aſcenſion counted in the Hour Circle from 12, in the middle thereof towards the left-hand, and extend the other foot, to the Stars Right Aſcenſion counted in the ſame Circle from 12 towards the Right hand. With this diſtance of the Compaſſes, ſet one foot in the Stars hour, counted on the left hand of 12, and the other foot being turned to the Right hand ſhall fall upon the true hour.

Thus the complement of the Suns Right Aſcenſion	h.	m.
upon the 23 of *December*- — — —	5	7
The *Bulls Eye* Right Aſcenſion — — —	4	16
The *Bulls Eye* horary diſtance from the Meridian being 6 d. high — —	6	42

Set one foot of the Compaſſes in 5 h. 7 m. of the hour Circle counted from the middle 12 to the left hand, (that is in 6 h. 53 m.) and extend the other foot

foot to 4 h. 16 m. counted from the middle 12. towards the right hand. With this extent of the Compasses, set one foot in 6 Hours 42 Minutes (the Stars hour) counted from the beginning, and the other foot will rest upon 4 h. 5 m. which is 5 m. past 4 in the morning, because the moveable point of the Compasses fell beyond the middle 12 in the hour Circle.

Example 2.

Upon the 31 of *December*, I observe the Altitude of the Great Dog to be 14 d. and I desire to know the hour of the night.

By the 15 Problem of the first, I find the great Dogs horary distance from the Meridian to be 9 h. 22 m.

	h.	m.
Comp. of the Suns R. Ascension *December* 31	4.	30
Right Ascension of the great Dog	6	30
Stars hour	9	22
	20	22
Deduct 12 hours, rests the hour of the night	8	22
	h.	m.

Set one foot of the Compasses in 4 30 counted from the middle 12 to the left hand and extend the other foot to 6h. 30m. counted from 12 to the right hand, the same extent will reach from 9 h. 22 m. counted from the beginning of the Circle, to 8 h. 22. the true hour of the night.

Example 3.

Upon the 5th of *January*, I observe the Altitude of the great Dog to be 15 d. high, and by the 15 before-going, the Stars hour to be 9 h. 32 m. Then

		h.	m.
The Comp. of the Suns R. Ascension *Jan.* 5.		4.	09
Right Ascension of great Dog		6.	30
Stars hour		9.	32
		20	11
Hour of the night		8.	11

Set one foot of the Compasses in 4 h. 9 m. counted from 12 to the left hand, and extend the other to 6 h. 30 m. counted from the middle 12 to the right hand. With this extent set one foot in 9 h. 32 m. counted from the beginning of the Circle, and the other foot will fall upon 8 hours 11 m. the true hour of the night.

And according to this Rule you may easily and readily find the true hour of the night at any time, of which take these following Examples for practise.

	d.	h.	m.
Decemb. 1. The *Bulls Eye* Altitude	39	7	12
Novem. 1. The *Bulls Eye* Altitude	30	9	2
May 15. *Arcturus* Altitude	50	11	3
Feb. 6. *Arcturus* Altitude	20	10	23

And by working with the Stars, as if they were the Sun, all or most of the problems in the first part may be performed; and now because the knowledg of the Suns Right Ascension is so absolutely necessary, I shall therefore here insert a Table of the complement of the Suns right Ascension from midnight, for every day in the year, as also a Table of the right Ascension and Declination of some eminent fixed Stars, with their use; and so I shall conclude this Second Part.

A Table of the Complement of the Suns Right Ascension at midnight, in Hours and Minutes.

Days.	January		February		March.		April.		May.		June.	
	h.	m	h.	m.	h.	m.	h.	m.	h.	m	h.	m.
1	4	25	2	18	0	32	10	39	8	46	6	41
2	4	21	2	14	0	28	10	35	8	42	6	37
3	4	17	2	10	0	24	10	31	8	38	6	33
4	4	13	2	6	0	21	10	27	8	34	6	29
5	4	9	2	2	0	17	10	24	8	30	6	24
6	4	4	1	58	0	14	10	20	8	26	6	20
7	4	0	1	54	0	10	10	16	8	22	6	16
8	3	56	1	50	0	7	10	13	8	18	6	12
9	3	51	1	46	0	3	10	9	8	14	6	8
10	3	47	1	43	11	59	10	6	8	10	6	4
11	3	43	1	39	11	55	10	2	8	6	6	0
12	3	38	1	35	11	52	9	58	8	2	5	56
13	3	34	1	31	11	48	9	54	7	58	5	52
14	3	30	1	27	11	45	9	50	7	54	5	48
15	3	26	1	24	11	41	9	47	7	50	5	43
16	3	22	1	20	11	37	9	43	7	16	5	39
17	3	18	1	16	11	34	9	39	7	12	5	35
18	3	14	1	12	11	30	9	35	7	38	5	31
19	3	10	1	8	11	27	9	31	7	34	5	27
20	3	6	1	5	11	23	9	28	7	30	5	22
21	3	2	1	1	11	19	9	24	7	26	5	18
22	2	57	0	57	11	16	9	20	7	22	5	14
23	2	53	0	54	11	12	9	16	7	18	5	10
24	2	49	0	50	11	8	9	12	7	14	5	6
25	2	45	0	47	11	5	9	9	7	10	5	2
26	2	41	0	43	11	1	9	5	7	6	4	58
27	2	37	0	39	10	57	9	1	7	2	4	54
28	2	33	0	35	10	54	8	57	6	58	4	50
29	2	29			10	50	8	53	6	54	4	46
30	2	25			10	46	8	50	6	49	4	41
31	2	22			10	43			6	45		

A Table of the Complement of the Suns Right Ascension at midnight in hours and minutes.

Dayes.	July.		August.		Septem.		October.		Novem.		Decem.	
	h.	m	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	4	37	2	35	0	41	10	52	8	53	6	45
2	4	33	2	31	0	37	10	48	8	49	6	49
3	4	29	2	27	0	34	10	45	8	45	6	35
4	4	25	2	23	0	30	10	41	8	41	6	31
5	4	21	2	20	0	27	10	38	8	37	6	26
6	4	17	2	16	0	23	10	34	8	33	6	22
7	4	13	2	12	0	19	10	30	8	29	6	18
8	4	9	2	9	0	16	10	26	8	24	6	13
9	4	5	2	5	0	12	10	22	8	20	6	9
10	4	1	2	2	0	9	10	19	8	15	6	4
11	3	57	1	58	0	5	10	15	8	11	6	0
12	3	53	1	54	0	1	10	11	8	7	5	55
13	3	49	1	50	11	58	10	7	8	2	5	51
14	3	45	1	46	11	54	10	3	7	58	5	46
15	3	41	1	43	11	51	10	0	7	53	5	41
16	3	37	1	39	11	47	9	56	7	49	5	36
17	3	33	1	35	11	43	9	52	7	45	5	32
18	3	29	1	32	11	40	9	48	7	41	5	27
19	3	25	1	28	11	36	9	44	7	37	5	23
20	3	21	1	25	11	33	9	40	7	32	5	19
21	3	17	1	21	11	29	9	36	7	28	5	15
22	3	13	1	17	11	25	9	32	7	24	5	11
23	3	9	1	14	11	22	9	28	7	20	5	6
24	3	5	1	10	11	18	9	24	7	15	4	2
25	3	2	1	7	11	15	9	21	7	11	4	57
26	2	58	1	3	11	11	9	17	7	7	4	53
27	2	54	0	58	11	7	9	13	7	3	4	49
28	2	50	0	56	11	3	9	9	6	58	4	44
29	2	46	0	52	10	59	9	5	6	54	4	40
30	2	48	0	49	10	56	9	1	6	49	4	35
31	2	39	0	45			8	57			4	30

A Table of the Right Aſcenſion and Semidiurnal Arks of ſome eminent fixed Stars throughout the Zodiack, for the ready finding of the time of their coming to the South, their Riſing, Setting, and hour of the night.

Names of the Stars.	Right Aſ. h.	Right Aſ. m	Sem. Ark h.	Sem. Ark m.
South Star in the Whales Tail	0	27	4	4
Andromedaes Girdle	0	51	10	6
The former horn of the Ram	1	36	7	39
The Whales Belly	1	36	4	56
Southern foot of Andromeda	1	43	ſets	not
The Whales Jaw	2	45	5	45
The brighteſt of the 7. Stars	3	28	8	16
Bulls Eye, Aldeboren.	4	17	7	27
The Goat Capella	4	52	ſets	not
Foremoſt ſhoulder of Orion	5	8	6	32
Orions Head	5	17	8	1
Middlemoſt in Orions Belt	5	20	5	52
The Great Dog	6	31	4	30
The Little Dog	7	22	6	32
The lowermoſt head of Twins	7	26	9	4
North Aſellus	8	23	8	14
South Aſellus	8	25	7	50
Lyons Heart	9	50	7	14
Lyons Tail	11	32	7	32
Vindemiatrix	0	46	7	9
Spica Virginis	1	8	5	11
Arcturus	2	1	8	2
Left ſhoulder of Boots	2	19	ſets	not

Stars

Stars Names	R. h.	As. m.	Se. h.	Ark m.
South Ballance	2	23	4	40
North Ballance	3	0	5	17
Bright Star of the Crown	3	25	8	57
Cor Scorpio, Antares	4	9	3	23
Hercules Right Shoulder	4	16	8	10
Hercules Head	5	0	7	22
Ophiucus Head	5	20	7	10
The Harp	6	22	sets	not
Vultures Tail	6	51	7	14
The Swans Bill	7	18	8	51
The Vulture	7	35	6	43
The lowermost horn of the Goat	8	3	4	33
Swans Breast	8	11	sets	not
Swans Tail	8	31	sets	not
Lowermost wing of the Swan	8	33	9	48
Girdle of Cephens	9	25	sets	not
Pegasus mouth	9	28	6	44
Right shoulder of the Waterbearer	9	47	5	50
Fomahanti	10	39	2	28
Scheat	10	48	8	42
Mercha	10	49	7	13
Head of Andromeda	11	52	8	51
Cassiopeah's Chair	11	53	sets	not

The uses of the Two former Tables.

The uses of these two Tables are principally these following.

1. *To find at what hour any of these Stars will be upon the Meridian any day or night.*
2. *To know at what hour any of them Riseth or Setteth.*
3. *To know how long it continues above the Horizon.*
4. *To find the hour of the Night, by seeing any of these Stars either upon the Meridian, or rising in the East or setting in West.*
5. *By having the horary distance of any of these Stars from the Meridian he was last upon (before called the Stars hour) to find thereby the hour of the night.*

The Stars in the former Table are so selected gradually through the Zodiack, that at any time some one or other of them will be either *Rising, Setting,* or else be upon the *Meridian,* Wherefore

I. *To find at what hour any of the Stars mentioned in the former Table, will be upon the Meridian.*

Add the Gomplement of the Suns Right Ascension for the day proposed, to the Right Ascension of the Star; the sum of them will be the time of that Stars being upon the Meridian.

Stars Names	R. As. h.	m.	Se. Ark h.	m.
South Ballance	2	23	4	40
North Ballance	3	0	5	17
Bright Star of the Crown	3	25	8	57
Cor Scorpio, Antares	4	9	3	23
Hercules Right Shoulder	4	16	8	10
Hercules Head	5	0	7	22
Ophiucus Head	5	20	7	10
The Harp	6	22	ſets	not
Vultures Tail	6	51	7	14
The Swans Bill	7	18	8	51
The Vulture	7	35	6	43
The lowermoſt horn of the Goat	8	3	4	33
Swans Breaſt	8	11	ſets	not
Swans Tail	8	31	ſets	not
Lowermoſt wing of the Swan	8	33	9	48
Girdle of Cephens	9	25	ſets	not
Pegaſus mouth	9	28	6	44
Right ſhoulder of the Waterbearer	9	47	5	50
Fomahanti	10	39	2	28
Scheat	10	48	8	42
Mercha	10	49	7	13
Head of Andromeda	11	52	8	51
Caſſiopeah's Chair	11	53	ſets	not

The

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4. *To find the hour of the Night, by seeing any of these Stars either upon the Meridian, or rising in the East or setting in West.*
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The Stars in the former Table are so selected gradually through the Zodiack, that at any time some one or other of them will be either *Rising*, *Setting*, or else be upon the *Meridian*, Wherefore

I. *To find at what hour any of the Stars mentioned in the former Table, will be upon the Meridian.*

Add the Gomplement of the Suns Right Ascension for the day proposed, to the Right Ascension of the Star; the sum of them will be the time of that Stars being upon the Meridian.

Example. Let it be required to know at what time the *Bulls Eye* will be upon the Meridian, upon the first of *January*, 1672.

	h.	m.
Complement of Suns Right Aſcenſion *Jan.* 1.-	4.	25
Right Aſcenſion of the *Bulls Eye*— ———————	4.	17
Bulls Eye will be upon the Meridian at——--	8.	42

And upon the 21 of *January* the *Bulls Eye* will be upon the Meridian at 7 h. and 19 m. after noon, as in Example

	h.	m.
Complem. of Suns Right Aſcenſion *Jan.* 21.---	3.	2
Right Aſcenſion of the *Bulls Eye*———————	4.	17
Bulls Eye upon the Meridian at ——————	7.	19

Again upon the ſame firſt of *January* the *Great Dog* will be upon the Meridian at 56 m. after 10 of the Clock, as in Example.

	h.	m
Complem. of Suns Right Aſcenſion *Jan.* 1.——	4.	25
The *Great Dogs* right Aſcenſion ——————-	6.	31
Great Dog upon the Meridian-———————	10.	56

And upon the 21 of *January*, at 33 m. after 9 of the Clock.

	h.	m.
Complement of the Suns right Aſcen. *Jan.* 21. —	3.	2
Great Dogs right Aſcenſion ————————	6.	31
Great Dog upon the Meridian————————	9.	33

II. To

II. *To know when any of these Stars do rise or Set.*

In thethird Columb of the Table you have the Semidiurnal Arch of each of the Stars, which being substracted from the time of the Stars being upon the Meridian, giveth the time of the Stars *Rising*, and being added thereunto giveth the time of the Stars *Setting*,

	h.	m.
Thus upon rhe first of *January* the *Bulls Eye* was found to be upon the Meridian at 8 h. 42 m.————	8.	42
From which substract his semidiurnal Ark----	7.	27
There rests————	1.	15

Wherefore the *Bulls Eye* that day, did *Rise* 15 m. after 1. of the Clock in the Afternoon, and by adding of the Stars Semidiurnal Ark, that Star did set at 9 m. after 4 the next morning, as in Example.

	h.	m.
Bulls Eye upon the Meridian, *Jan* 1. at——-	7.	42
The Semidiurnal Arch————	7.	27
The Bulls Eye sets (deducting 12 hours) at——-	16.	09
	12.	00
	4.	09

III. *To know how long any of these Stars do continue above the Horizon.*

The Semidiurnal Arch of the Star being doubled gives the time of that Stars continuance above the Horizon.

So the Semidiurnal Arch of the *Great Dog* being 4. hours 30 m. that doubled makes 9 hours, and so

long doth that Star continue above the Horizon; and this 9 hours being taken from 24 hours, there rests 15. hours, and so long doth this Star continue under the Horizon.

IV. *To find the hour of the night by any of these Stars.*

I. *By any of the Stars being upon the Meridian.*

Example. Upon the 6th of *December*, I see the *Bulls Eye* upon the South part of the Meridian, and I would know what hour of the night it is.

This is no other but the same with finding of what hour any Star will be upon the Meridian.

Wherefore to 6 hours 22 min. the Complement of the Right Ascension of the *Sun* for the day proposed, (viz. *December* 6.) add the Right Ascension of the *Bulls Eye* (*viz* 4 h. 17 m.) and the sum of them will be 10 hours and 39 m. So that seeing the *Bulls Eye* upon the Meridian upon the 6th of *December*, you may conclude the hour of the night to be 39 m. past 10 of the Clock.

II. *By seeing any of the Stars Rising or Setting.*

If upon the 15th of *October* I should see *Cor Scorpio*, (or the *Scorpions heart*) rising, and from thence would know the time of the night.

First, Seek by the first precept, at what time *Cor Scorpio* comes to the Meridian on the 15 of *October*, which you shall find to be at 2 hours and 9 m. in the morning, from which substract the Stars semidiurnal

nal Ark, 3 h. 23 m. (by adding 12 hours) and there will remain 10 hours 46 m. at night; so that upon the 15 of *October*, when you see *Cor Scorpio* Rising you may conclude it to be 46 m. past 10 at night.

But if upon the same day early in the morning, you should see *Cor Scorpio*, a setting and would know then the hour, you must then add 3 hours 23 m. (the *Semidiurnal* Ark) to 2 hours 9 m. (the Stars being upon the Meridian) and the Sum will be 5 hours 32 m. So that when you see *Cor Scorpio* setting upon the 15th of *October*, you may conclude the hour to be 32 m. past 5 in the morning.

V. *By having the Stars hour, to find thereby the hour of the night.*

Add the Stars hour, the Stars right Ascension, and the Complement of the Suns Right Ascension all three together, the sum is the hour required, as in the following Examples.

Example 1. *By the* Bulls Eye Decemb. 11.

	h.	m.
Stars hour	8.	56
Suns Ascension compl.	6.	09
Stars Ascension	4.	17
	19.	13
	12.	10
Hour of the night	7.	13

Exam-

Example 2. *By the* Great Dog Decemb. 31.

	h.	m.
Stars hour	9.	22
Suns R. Aſcenſion Comp.	4.	30
Stars R. Aſcenſion	6.	31
	20.	23
	12.	00
Hour of the night	8.	23

Example 3. *By the* Great Dog Jan. 3.

Stars Hour	9.	33
Comp. of the Suns R. Aſcenſion	4.	09
Stars R. Aſcenſion	6.	31
	20.	13
	12.	00
Hour of the night	8.	13

Example 4. *By the* Bulls Eye November 1.

Stars hour	7.	54
Stars R. Aſcenſion	4.	17
Suns R. Aſcenſion Compl.	8.	53
	21.	04
	12.	00
The hour of the night	9.	04

Exam-

Example 5. By Arcturus May 15.

Stars hour	2.13
Suns R. Aſcenſion Compl:	7 50
Stars R. Aſcenſion	2. 01
Hour of the night	10. 04

Example 6. By Arcturus February 6.

Stars hour	6. 24
Stars R. Aſcenſion	2. 01
Comp. of the Suns R. Aſcenſion	1. 58
Hour of the night	10. 23

Many more Examples, and other *Uſes* of theſe Tables might be inſerted, but at this time let this ſuffice.

FINIS.

Lawrence Faierclough 1685

LAWRENCE FAIERCLOUGH 1688

Lawrence Faierclough: 1696

Example 2. *By the* Great Dog Decemb. 31.

	h.	m.
Stars hour	9.	22
Suns R. Aſcenſion Comp.	4.	30
Stars R. Aſcenſion	6.	31
	20.	23
	12.	00
Hour of the night	8.	23

Example 3. *By the* Great Dog Jan. 3.

Stars Hour	9.	33
Comp. of the Suns R. Aſcenſion	4.	09
Stars R. Aſcenſion	6.	31
	20.	13
	12.	00
Hour of the night	8.	13

Example 4. *By the* Bulls Eye November 1.

Stars hour	7.	54
Stars R. Aſcenſion	4.	17
Suns R. Aſcenſion Compl.	8.	53
	21.	04
	12.	00
The hour of the night	9.	04

Exam-

Example 5. *By* Arcturus May 15.

Stars hour	2. 18
Suns R. Ascension Compl:	7. 50
Stars R. Ascension	2. 01
Hour of the night	10. 04

Example 6. *By* Arcturus February 6.

Stars hour	6. 24
Stars R. Ascension	2. 01
Comp. of the Suns R. Ascension	1. 58
Hour of the night	10. 23

Many more Examples, and other *Uses* of these Tables might be inserted, but at this time let this suffice.

FINIS.

Lawrence Faierclough 1685

LAWRENCE FAIERCLOVGH 1688

Lawrence Faierclough 1696

Regnall table to ye year 1686

	Kings Names		Born Anno	Began to Reign	Reigned Y	M	Since their Reigns	ended	Buryed
1	William	1	1023	1066 oct 14	20	11	58	sept 9	Caen in normondy
2	William	2	1057	1087 Sept 9	12	11	5	Aug 2	winchester
3	Henry	1	1068	1100 Aug 2	35	3	5	dec 1	Reading
4	Steven		1105	1135 dec 1	18	10	5	oct 25	feversham
5	Henry	2	1132	1154 oct 25	35	9	4	July 06	fountevers
6	Richard	1	1155	1189 July 6	9	9	4	Apr 6	fountevrr
7	John		1165	1199 Apr 6	17	6	4	oct 19	worcester
8	Henry	3	1207	1216 oct 19	56	1	4	nov 16	westminster
9	Edward	1	1239	1272 no 16	34	8	3	July 7	westminster
10	Edward	2	1283	1307 July 7	19	6	3	Jan 25	glocester
11	Edward	3	1312	1326 Jan 25	51	5	3	June 21	westminster
Rich 12		2	1366	1377 June 21	22	3	2	sept 29	westminster
13	Henry	4	1367	1399 sept 29	13	6	2	mar 20	Canterbury
14	Henry	5	1384	1412 Mar 20	9	5	2	Aug 31	westminster
15	Henry	6	1421	1422 Aug 31	38	6	2	mar 4	Windsor
16	Edward	4	1442	1460 mar 4	22	1	2	Apr 9	Winchester
17	Edward	5	1473	1483 Apr 9	0	2	2	June 18	not known where
18	Richard	3	1448	1483 June 22	2	2	2	Aug 22	leister
19	Henry	7	1455	1485 Aug 22	23	11	1	Apr 22	Westminster
20	Henry	8	1491	1509 Apr 22	37	9	1	Jan 28	windsor
21	Edward	6	1537	1546 Jan 28	6	5	1	July 6	westminster
22	qu. mary		1518	1553 July 6	5	4		nov 17	westminster
23	qu. Eliz		1533	1558 nov 17	44	4		mar 24	Westminster
24	James	1	1566	1602 Mar 24	22	0		mar 27	Westminster
25	Chaarls	1	1600	1625 Mar 27	13	11		Jan 30	windsor
26	Charls	2	1630	1648 Jan 30	36	0	[illegible]	febr 14	westminster
27	James	2	1633	1684 feb 6	3	9			
28	william & mary			1688 feb 13					

GN	A	B	C	D	E	F	G
1	Apr 9	Apr 10	Apr 11	Apr 12	Apr 6	Apr 7	Apr 8
2	Mar 26	Mar 27	Mar 28	Mar 29	Mar 30	Mar 31	Apr 1
3	Apr 16	Apr 17	Apr 18	Apr 19	Apr 20	Apr 14	Apr 15
4	Apr 9	Apr 3	Apr 4	Apr 5	Apr 6	Apr 7	Apr 8
5	Mar 26	Mar 27	Mar 28	Mar 29	Mar 23	Mar 24	Mar 25
6	Apr 16	Apr 17	Apr 11	Apr 12	Apr 13	Apr 14	Apr 15
7	Apr 2	Apr 3	Apr 4	Apr 5	Apr 6	Mar 31	Apr 1
8	Apr 23	Apr 24	Apr 25	Apr 19	Apr 20	Apr 21	Apr 22
9	Apr 9	Apr 10	Apr 11	Apr 12	Apr 13	Apr 14	Apr 8
10	Apr 2	Apr 3	Mar 28	Mar 29	Mar 30	Mar 31	Apr 1
11	Apr [illegible]	Apr 17	Apr 18	Apr 19	Apr 20	Apr 21	Apr 22
12	Apr 9	Apr 10	Apr 11	Apr 5	Apr 6	Apr 7	Apr 8
13	Mar 26	Mar 27	Mar 28	Mar 29	Mar 30	Mar 31	Mar 25
14	Apr 16	Apr 17	Apr 18	Apr 19	Apr 13	Apr 14	Apr 15
15	Apr [illegible]	Apr 3	Apr [illegible]	Apr [illegible]	Apr 6	Apr 7	Apr 8
16	Mar 26	Mar 27	Mar 28	Mar 22	Mar 23	Mar 24	Mar 25
17	Apr 16	Apr 10	Apr 11	Apr 12	Apr 13	Apr 14	Apr 15
18	Apr 2	Apr 3	Apr 4	Apr 5	Mar 30	Mar 31	Apr 1
19	Apr 23	Apr 24	Apr 18	Apr 19	Apr 20	Apr 21	Apr 22

take this for A General Rule —

ye same day 7 weeks (before / after) Easter is {shrove sunday / whit sunday}

A fortnight before {shrove sunday / whit sunday} is {septuagesima / Rogation sunday}

ye sunday after {shrove sunday / whit sunday} is {quadragesima / trinity sunday}

Allsoe whensoever ye Golden Number is 3 6 9 12 15 18 yn ye Epact is ye same

But when

ye Golden Num: is	I	2	4	5	7	8	10	11	13	14	16	17	19
yn ye Epact is	11	22	14	25	17	28	20	I	23	4	26	7	29

this table shewth the dominical leter From ye F[illegible] iear of ✝ to 3400 & consequently for ever

Lawrence-Faierclough

1	6	3	8	5	7	4
9		11		2	10	12
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

A Perpetual Allman

				DC	ED	FE	GF	AG	BA	CB
				000 700 1400 2100 2800	100 800 1500 2200 2900	200 900 1600 2300 3000	300 1000 1700 2400 3100	400 1100 1800 2500 3200	500 1200 1900 2600 3300	600 1300 2000 2700 3400
0	28	56	84	DC	ED	FE	GF	AG	BA	CB
1	29	57	85	B	C	D	E	F	G	A
2	30	58	86	A	B	C	D	E	F	G
3	31	59	87	G	A	B	C	D	E	F
4	32	60	88	FE	GF	AG	BA	CB	DC	ED
5	33	61	89	D	E	F	G	A	B	C
6	34	62	90	C	D	E	F	G	A	B
7	35	63	91	B	C	D	E	F	G	A
8	36	64	92	AG	BA	CB	DC	ED	FE	GF
9	37	65	93	F	G	A	B	C	D	E
10	38	66	94	E	F	G	A	B	C	D
11	39	67	95	D	E	F	G	A	B	C
12	40	68	96	CB	DC	ED	FE	GF	AG	BA
13	41	69	97	A	B	C	D	E	F	G
14	42	70	98	G	A	B	C	D	E	F
15	43	71	99	F	G	A	B	C	D	E
16	44	72		ED	FE	GF	AG	BA	CB	DC
17	45	73		C	D	E	F	G	A	B
18	46	74		B	C	D	E	F	G	A
19	47	75		A	B	C	D	E	F	G
20	48	76		GF	AG	BA	CB	DC	ED	FE
21	49	77		E	F	G	A	B	C	D
22	50	78		D	E	F	G	A	B	C
23	51	79		C	D	E	F	G	A	B
24	52	80		BA	CB	DC	ED	FE	GF	AG
25	53	81		G	A	B	C	D	E	F
26	54	82		F	G	A	B	C	D	E
27	55	83		E	F	G	A	B	C	D

moveable feasts for ever are found by Domini
Leter and the Golden Number

Dominical Leter	Golden Number	from [illegible] to Shrove Sunday	Shrove Sunday	Easter day	Rogat Sunday	Asens day	whit Sund	Trinity Sund	Advent Sund
A	2.5.13.16	6 weeks	feb 5	mar 26	Apr 30	may 4	may 14	may 21	Dec 3
	~~7.10.15.18~~	7 weeks	feb 12	~~Apr 2~~	~~may 7~~	~~may 11~~	may 21	may 28	Dec 3
	~~1.4.9.12~~	8 weeks	feb 19	Apr 9	~~may 14~~	~~may 18~~	may 28	June 4	Dec 3
	3.6.11.14.17	9 weeks	feb 26	Apr 16	may 21	may 25	June 4	June 11	Dec 3
	9.19	10 weeks	mar 5	Apr 23	may 28	June 1	June 11	June 18	Dec 3
B	2.5.13.16	6 weeks 1 day	feb 6	mar 27	may 1	may 5	may 15	may 22	nov 27
	4.7.10.15.18	7 weeks 1 day	feb 13	Apr 3	may 8	may 12	may 22	may 29	nov 27
	1.9.12.17	8 weeks 1 day	feb 20	Apr 10	may 15	may 19	may 29	June 5	nov 27
	3.6.11.14	9 weeks 1 day	feb 27	Apr 17	may 22	may 26	June 5	June 12	nov 27
	8.19	10 weeks 1 day	mar 6	Apr 24	may 29	June 2	June 12	June 19	nov 27
C	2.5.10.13.16	6 weeks 2 day	feb 7	mar 28	may 2	may 6	may 16	may 23	nov 28
	4.7.15.18	7 weeks 2 day	feb 14	Apr 4	may 9	may 13	may 23	may 30	nov 28
	1.6.9.12.17	8 weeks 2 day	feb 21	Apr 11	may 16	may 20	may 30	June 6	nov 28
	3.11.14.19	9 weeks 2 day	feb 28	Apr 18	may 23	may 27	June 6	June 13	nov 28
	8	10 weeks 2 day	mar 7	Apr 25	may 30	June 3	June 13	June 20	nov 28
D	16	5 weeks 3 day	feb 1	mar 22	Apr 26	Apr 30	may 10	may 17	nov 29
	2.5.10.13	6 weeks 3 day	feb 8	mar 29	may 3	may 7	may 17	may 24	nov 29
	4.7.12.15.18	7 weeks 3 day	feb 15	Apr 5	may 10	may 14	may 24	may 31	nov 29
	1.6.9.17	8 weeks 3 day	feb 23	Apr 12	may 17	may 21	may 31	June 7	nov 29
	3.8.11.14.19	9 weeks 3 day	mar 1	Apr 19	may 24	may 28	June 7	June 14	nov 29
E	5.16	5 weeks 4 day	feb 2	mar 23	Apr 27	may 1	may 11	may 18	nov 30
	2.10.13.18	6 weeks 4 day	feb 9	mar 30	may 4	may 8	may 18	may 25	nov 30
	1.4.7.12.15	7 weeks 4 day	feb 16	Apr 6	may 11	may 15	may 25	June 1	nov 30
	6.9.14.17	8 weeks 4 day	feb 23	Apr 13	may 18	may 22	June 1	June 8	nov 30
	3.8.11.19	9 weeks 4 day	mar 2	Apr 20	may 25	may 29	June 8	June 15	nov 30
F	5.16	5 weeks 5 day	feb 3	mar 24	Apr 28	may 2	may 12	may 19	Dec 1
	2.7.10.13.18	6 weeks 5 day	feb 10	mar 31	may 5	may 9	mey 19	may 26	Dec 1
	1.4.12.15	7 weeks 5 day	feb 18	Apr 7	may 12	may 16	may 26	June 2	Dec 1
	3.6.9.14.17	8 weeks 5 day	feb 24	Apr 14	may 19	may 23	June 2	June 9	Dec 1
	8.11.19	9 weeks 5 day	mar 3	Apr 21	may 26	may 30	June 9	June 16	Dec 1
G	5.13.16	5 weeks 6 day	feb 4	mar 25	Apr 29	may 3	may 13	may 20	Dec 2
	2.7.10.18	6 weeks 6 days	feb 11	Apr 1	may 6	may 10	may 20	may 27	Dec 2
	1.4.9.12.15	7 weeks 6 days	feb 18	Apr 8	may 13	may 17	may 27	June 3	Dec 2
	3.6.14.17	8 weeks 6 day	feb 25	Apr 15	may 20	may 24	June 3	June 10	Dec 2
	8.11.19	9 weeks 6 day	mar 4	Apr 22	may 27	may 31	June 10	June 17	Dec 2

Golden Number (or prime) is Readily Found forth by this table for ever -

[illegible]	1	8	17	22	[illegible]	nov
Aug	2	9	16	23	[illegible]	[illegible]
may	3	10	17	24	31	Jan
Oct	4	11	18	25		Oct
July	5	12	19	26		apr
Sept	6	13	20	27		dec
June	7	14	21	28		Feb

Lawrence: Faierclough

1	6	3	8	5	7	4
9		11		2	10	12
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	6	8	5

everlasting: Almanack

Tempus Fugit -

							100	200	300	400	500	600	700	800	900
							6	11	16	2	7	12	17	3	8
							2000	2100	2200	2300	2400	2500	2600	2700	2800
2	1	20	39	58	77	96	7	12	17	3	8	13	18	04	9
3	2	21	40	59	78	97	8	13	18	4	9	14	19	05	10
4	3	22	41	60	79	98	9	14	19	5	10	15	1	06	11
5	4	23	42	61	80	99	10	15	1	6	11	16	2	07	12
6	5	24	43	62	81		11	16	2	7	12	17	3	08	13
7	6	25	44	63	82		12	17	3	8	13	18	4	09	14
8	7	26	45	64	83		13	18	4	9	14	19	5	10	15
9	8	27	46	65	84		14	19	5	10	15	1	6	11	16
10	9	28	47	66	85		15	1	6	11	16	2	7	12	17
11	10	29	48	67	86		16	2	7	12	17	3	8	13	18
12	11	30	49	68	87		17	3	8	13	18	4	9	14	19
13	12	31	50	69	88		18	4	9	14	19	5	10	15	1
14	13	32	51	70	89		19	5	10	15	1	6	11	16	2
15	14	33	52	71	90		1	6	11	16	2	7	12	17	3
16	15	34	53	72	91		2	7	12	17	3	8	13	18	4
17	16	35	54	73	92		3	8	13	18	4	9	14	19	5
18	17	36	55	74	93		4	9	14	19	5	10	15	1	6
19	18	37	56	75	94		5	10	15	1	6	11	16	02	7
1	19	38	57	76	95		6	11	16	2	7	12	17	03	8

						1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
						13	18	4	9	14	19	5	10	15	1
						2900	3000	3100	3200	3300	3400	3500	3600	3700	3800
1	20	39	58	77	96	14	19	5	10	15	1	6	11	16	2
2	21	40	59	78	97	15	1	6	11	16	2	7	12	17	3
3	22	41	60	79	98	16	2	7	12	17	3	8	13	18	4
4	23	42	61	80	99	17	3	8	13	18	4	9	14	19	5
5	24	43	62	81		18	4	9	14	19	5	10	15	1	6
6	25	44	63	82		19	5	10	15	1	6	11	16	2	7
7	26	45	64	83		1	6	11	16	2	7	12	17	3	8
8	27	46	65	84		2	7	12	17	3	8	13	18	4	9
9	28	47	66	85		3	8	13	18	4	9	14	19	5	10
10	29	48	67	86		4	9	14	19	5	10	15	1	6	11
11	30	49	68	87		5	10	15	1	6	11	16	2	7	12
12	31	50	69	88		6	11	16	2	7	12	17	3	8	13
13	32	51	70	89		7	12	17	3	8	13	18	4	9	14
14	33	52	71	90		8	13	18	4	9	14	19	5	10	15
15	34	53	72	91		9	14	19	5	10	15	1	6	11	16
16	35	54	73	92		10	15	1	6	11	16	2	7	12	17
17	36	55	74	93		11	16	2	7	12	17	3	8	13	18
18	37	56	75	94		12	17	3	8	13	18	4	9	14	19
19	38	57	76	95		13	18	4	9	14	19	5	10	15	1

A Table to find the moveable feasts for ever by y^e Dom-Leter & Golden Nu[illegible] & y^e moveable terms for ever

Dominical Letter	Golden Number	from xmas to Shroue Sunday		Shroue Sunday	E[illegible] day	Rogat Sunday	Ascens day	[illegible] Sund	Trinity Sunday	Advent Sunday	Easter term begin	Easter term ends	Trinity term begin	Trinity term ends
A	2·5·13·16	6 weeks	------	feb 5	march 26	Apr 30	may 4	may 14	may 21	dec 3	Apr 12	may 8	may 26	June 14
	7·10·15·18	7 weeks	----	febu 12	April 2	may 7	may 11	may 21	may 28	dec 3	Apr 19	may 1[illegible]	June 2	June 21
	1·4·9·12	8 weeks	----	febv 19	April 9	may 14	may 18	may 28	June 4	dec 3	Apr 26	may 22	June 9	June 28
	3·6·11·14·17	9 weeks	----	febv 26	April 16	may 21	may 25	June 4	June 11	dec 3	may 3	may 2[illegible]	June 16	July 5
	8·19 ---	10 weeks	----	march 5	April 23	may 28	June 1	June 11	June 18	dec 3	may 10	June 5	June 23	July 12
B	2·5·13·16	6 weeks	1 day	febu 6	march 27	may 1	may 5	may 15	may 22	nov 27	Apr 13	may 9	may 27	June 15
	4·7·10·15·18	7 weeks	1 day	febv 13	April 3	may 8	may 12	may 22	may 29	nov 27	Apr 20	may 16	June 3	June 22
	1·9·12·17	8 weeks	1 day	febv 20	April 10	may 15	may 19	may 29	June 5	nov 27	Apr 27	may 23	June 10	June 29
	3·6·11·14	9 weeks	1 day	febv 27	April 17	may 22	may 26	June 5	June 12	nov 27	may 4	may 31	June 17	July 6
	8·19 ---	10 weeks	1 day	march 6	April 24	may 29	June 2	June 12	June 19	nov 27	may 11	June 6	June 24	July 13
C	2·5·10·13·16	6 weeks	2 days	febv 7	march 28	may 2	may 6	may 16	may 23	nov 28	Apr 14	may 10	may 28	June 16
	4·7·15·18	7 weeks	2 days	febv 14	April 4	may 9	may 13	may 23	may 30	nov 28	April 21	may 17	June 4	June 23
	1·6·9·12·17	8 weeks	2 days	febv 21	April 11	may 16	may 20	may 30	June 6	nov 28	Apr 28	may 24	June 11	June 30
	3·11·14·19	9 weeks	2 days	febv 28	April 18	may 23	may 27	June 6	June 13	nov 28	May 5	may 31	June 18	July 7
	8 ----	10 weeks	2 days	febvch 7	April 25	may 30	June 3	June 13	June 20	nov 28	May 12	June 7	June 25	July 14
D	16 ----	5 weeks	3 days	febu 1	march 2[illegible]	Apr 26	Apr 30	may 10	may 17	nov 29	Apr [illegible]	may 4	may 22	June 10
	2·5·10·13	6 weeks	3 days	febu 8	march 2[illegible]	may 3	may 7	may 17	may 24	nov 29	Apr 15	may 11	may 29	June 17
	4·7·12·15·18	7 weeks	3 days	febu 15	April 5	may 10	may 14	may 24	may 31	nov 29	Apr 22	may 18	June 5	June 24
	1·6·9·17	8 weeks	3 days	febu 22	April 12	may 17	may 21	may 31	June 7	nov 29	Apr 29	may 25	June 12	July 1
	3·8·11·14·19	9 weeks	3 days	march 1	April 19	may 24	may 28	June 7	June 14	nov 29	may 6	June 1	June 19	July 8
E	5·16 ---	5 weeks	4 days	febu 2	march 23	Apr 27	may 1	may 11	may 18	nov 30	Apr 9	may 5	may 23	June 11
	2·10·13·18	6 weeks	4 days	febu 9	march 30	may 4	may 8	may 18	may 25	nov 30	Apr 16	may 12	may 30	June 18
	1·4·7·12·15	7 weeks	4 days	febu 16	April 6	may 11	may 15	may 25	June 1	nov 30	Apr 23	may 19	June 6	June 25
	6·9·14·17	8 weeks	4 days	febu 23	April 13	may 18	may 22	June 1	June 8	nov 30	Apr 30	may 26	June 13	July 2
	3·8·11·19	9 weeks	4 days	march 2	April 20	may 25	may 29	June 8	June 15	nov 30	may 7	June 2	June 20	July 9
F	5·16 ---	5 weeks	5 days	febu 3	march 24	Apr 28	may 2	may 12	may 19	dec 1	Apr 10	may 6	may 24	June 12
	2·7·10·13·18	6 weeks	5 days	febu 10	march 31	may 5	may 9	may 19	may 26	dec 1	Apr 17	may 13	may 31	June 19
	1·4·12·15	7 weeks	5 days	febu 17	April 7	may 12	may 16	may 26	June 2	dec 1	Apr 24	may 20	June 7	June 26
	3·6·9·14·17	8 weeks	5 days	febu 24	April 14	may 19	may 23	June 2	June 9	dec 1	may [illegible]	may 27	June 14	July 3
	8·11·19 -	9 weeks	5 days	march 2[illegible]	April 21	may 26	may [illegible]	June 9	June 16	dec 1	may 8	June 3	June 2[illegible]	July 10
G	5·13·16	5 weeks	6 days	febu 4	march 25	Apr 29	may 3	may 13	may 20	dec 2	Apr 11	may 7	may 25	June 13
	2·7·10·18	6 weeks	6 days	febu 11	April 1	may 6	may 10	may 20	may 27	dec 2	Apr 18	may 14	June 1	June 20
	1·4·9·12·15	7 weeks	6 days	febu 18	April 8	may 13	may 17	may 27	June 3	dec 2	Apr 25	may 2[illegible]	June 8	June 27
	3·6·14·17	8 weeks	6 days	febu 25	April 15	may 20	may 24	June 3	June 10	dec 2	may 2	may 28	June 15	July 4
	8·11·19	9 weeks	6 days	march 4	April 22	may 27	may 31	June 10	June 17	dec 2	may 9	June 4	June 22	July 11
				·23·18										

A table
to find out y^e moueable terms
for ever

— A Table to find out y^e Moueable Terms for euer. —

dominicall Leter	Golden Number	Easter terme begin	Easter terme Ends	trinity terme begin	trinity terme Ends
A	2·5·13·16 7·10·15·18 1·4·9·12 3·6·11·14·17 8·19	Apr. 12 Apr. 19 Apr. 26 may 3 may 10	may 8 may 15 may 22 may 29 June 5	may 26 June 2 June 9 June 16 June 23	June 14 June 21 June 28 July 5 July 12
B	2·5·13·16 4·7·10·15·18 1·9·12·17 3·6·11·14 8·19	Apr 13 Apr 20 Apr 27 may 4 may 11	may 9 may 16 may 23 may 30 June 6	may 27 June 3 June 10 June 17 June 24	June 15 June 22 June 29 July 6 July 13
C	2·5·10·13·16 4·7·15·18 1·6·9·12·17 3·11·14·19 8	Apr 14 Apr 21 Apr 28 may 5 may 12	may 10 may 17 may 24 may 31 June 7	may 28 June 4 June 11 June 18 June 25	June 16 June 23 June 30 July 7 July 1[illegible]
D	16 2·5·10·13 4·7·12·15·18 1·6·9·17 3·8·11·14·19	Apr 8 Apr 15 Apr 22 Apr 29 may 6	may 4 may 11 may 18 may 25 June 1	may 22 may 29 June 5 June 12 June 19	June 10 June 17 June 24 July 1 July 8
E	5·16 2·10·13·18 1·4·7·12·15 6·9·14·17 3·8·11·19	Apr 9 Apr 16 Apr 23 Apr 30 may 7	may 5 may 12 may 19 may 26 June 2	may 23 may 30 June 6 June 13 June 20	June 11 June 18 June 25 July 2 July 9
F	5·16 2·7·10·13·18 1·4·12·15 3·6·9·14·17 8·11·19	Apr 10 Apr 17 Apr 24 may 1 may 8	may 6 may 13 may 20 may 27 June 3	may 24 may 31 June 7 June 14 June 21	June 12 June 19 June 26 July 3 July 10
G	5·13·16 2·7·10·18 1·4·9·12·15 3·6·14·17 8·11·19	Apr 11 Apr 18 Apr 25 may 2 may 9	may 7 may 14 may 21 may 28 June 4	may 25 June 1 June 8 June 15 June 22	June 13 June 20 June 27 July 4 July 11

Length of y^e 4 term^s … { hilary term is 20 day^s; Easter term is 26 days; trinity term is 19 days; Mich term is 36 days } Long

Easter term alway^s begin on WEDENDAY fortnight after easter day: & end^s on
ONDAY before whitsonday & is 26 days long=

rinity term euer beginneth on FRIDAY seauen-night after whit-sonday
alway^s end on WEDENSDAY fortnight after & is 19 day^s long=

EP	GN	DL	AD
1	11	GF	1644
12	12	E	1645
23	13	D	1646
4	14	C	1647
15	15	BA	1648
26	16	G	1649
17	17	F	1650
18	18	E	1651
29	19	DC	1652
11	1	B	1653
22	2	A	1654
3	3	G	1655
14	4	FE	1656
25	5	D	1657
6	6	C	1658
17	7	B	1659
28	8	AG	1660
0	9	F	1661
20	10	E	1662
1	11	D	1663
12	12	CB	1664
23	13	A	1665
4	14	G	1666
15	15	F	1667
26	16	ED	1668
7	17	C	1669
18	18	B	1670
29	19	A	1671
11	1	GF	1672
22	2	E	1673
3	3	D	1674
14	4	C	1675
25	5	BA	1676
6	6	G	1677
17	7	[illegible]E	1678
28	8	E[illegible]	1679
9	9	DC	1680
20	10	[illegible]B	1681
1	11	[illegible]A	1682
12	12	G	1683
23	13	FE	1684
4	14	D	1685
15	15	C	1686
26	16	B	1687
7	17	AG	1688
18	18	F	1689
29	19	E	1690
11	1	D	1691
22	2	CB	1692
3	3	A	1693
14	4	G	1694
25	5	F	1695
6	6	ED	1696
17	7	C	1697
28	8	B	1698
9	9	A	1699

15	15	C	1686	sunday Leter	2	10		9	6	3	11	weeke day's Leter	1695	F	5	25
26	16	B	1687		5	7	4	12			8		1696	ED	6	6
7	17	AG	1688			2	3	4	5	6	7		1697	C	7	17
18	18	F	1689		8	9	10	11	12	13	14		1698	B	8	28
29	19	E	1690		15	16	17	18	19	20	21		1699	A	9	9
11	1	D	1691		22	23	24	25	26	27	28		1700	GF	10	20
22	2	CB	1692		29	30	31						1701	E	11	1
3	3	A	1693		G	F	E	D	C	B	A		1702	D	12	12
14	4	G	1694		S	M	T	W	T	F	S		1703	C	13	23

Mar	1	8	15	22	29	Nov	1	6	3	8	5	7	4
Aug	2	9	16	23	30	Aug	9		11		2	10	12
may	3	10	17	24	31	Jan	1	2	3	4	5	6	7
oct	4	11	18	25		oct	8	9	10	11	12	13	14
July	5	12	19	26		Apr	15	16	17	18	19	20	21
Sept	6	13	20	27		Dec	22	23	24	25	26	27	28
June	7	14	21	28		feb	29	30	31				

	AG	FE	EC	D	CE	BF	AG
Jan 31	sund	sater	frid	thur	wen	tuesd	mon
feb 28	wen	tues	mon	sun	sater	frid	thur
mar 31	wen	tues	mon	sun	sater	frid	thur
Apr 30	sater	frid	thur	wen	tues	mon	sun
may 31	mon	sun	sater	frid	thur	wen	tues
June 30	thur	wen	tues	mon	sund	sater	frid
July 31	sater	frid	thur	wen	tues	mon	sund
Aug 31	tues	mon	sun	sater	frid	thur	wen
Sep 30	frid	thur	wen	tues	mon	sun	sater
oct 31	sund	sater	frid	thur	wen	tues	mon
nov 30	wen	tues	mon	sun	sater	frid	thur
dec 31	frid	thru	wen	tues	mon	sun	sater

this table sheweth ye first day yt every month begins throwout ye year — as for example ye dominicall Leter for this year is D — 1685 — underneath wch is thursday & sunday the wch sheweth on ye left hand yt ye 1st day of Jan is on a thursday & ye 1st of feb is on sunday — But in leap years as in 1688 — there is 2 dom. leters as A-G — ye 1st sheweth Jan & feb — ye other all ye year after — as A is sunday so G is on monday — &c —

EP	GN	DL	AD
20	10	GF	[illegible]
1	11	E	[illegible]
12	12	D	[illegible]
23	13	C	[illegible]
4	14	BA	[illegible]
15	15	G	[illegible]
26	16	F	[illegible]
7	17	E	[illegible]
18	18	DC	[illegible]
29	19	B	[illegible]
[illegible]	1	A	[illegible]
22	2	G	[illegible]
3	3	FE	[illegible]
14	4	D	[illegible]
25	5	C	[illegible]
6	6	B	[illegible]
17	7	AG	[illegible]
28	8	F	[illegible]
9	9	E	[illegible]
20	10	D	[illegible]
1	11	CB	[illegible]
12	12	A	[illegible]
23	13	G	[illegible]
4	14	F	[illegible]
15	15	ED	[illegible]
26	16	C	[illegible]
7	17	B	[illegible]
18	18	A	[illegible]
29	19	GF	[illegible]
11	1	E	[illegible]
22	2	D	[illegible]
3	3	C	[illegible]
14	4	BA	[illegible]
25	5	G	[illegible]
6	6	F	[illegible]
17	7	E	[illegible]
28	8	DC	[illegible]
9	9	B	[illegible]
20	10	A	[illegible]
1	11	G	[illegible]
12	12	FE	[illegible]
23	13	D	[illegible]
4	14	C	[illegible]
15	15	B	[illegible]
26	16	AG	[illegible]
7	17	F	[illegible]
18	18	E	[illegible]
29	19	D	[illegible]
11	1	CB	[illegible]
22	2	A	[illegible]
3	3	[illegible]	[illegible]
14	4	[illegible]	[illegible]
25	5	[illegible]	[illegible]
6	6	[illegible]	[illegible]
17	7	[illegible]	[illegible]
28	8	[illegible]	[illegible]

…le 5 tables … [Sh]ewth y^e Epact G N dom leter & y^e yeare of y^e lord [illegible] 1660 -- to -- 1829

EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD
[illegible]	5	FE	1600	23	13	D	1646	22	2	CB	1692	20	10	A	1738	18	18	GF	1784
[illegible]	6	D	1601	4	14	C	1647	3	3	A	1693	I	II	G	1739	29	19	E	1785
7	7	C	1602	15	15	BA	1648	14	4	G	1694	12	12	FE	1740	11	1	D	1786
8	8	B	1603	26	16	G	1649	25	5	F	1695	23	13	D	1741	22	2	C	1787
9	9	AG	1604	7	17	F	1650	6	6	ED	1696	4	14	C	1742	3	3	BA	1788
20	10	F	1605	18	18	E	1651	17	7	C	1697	15	15	B	1743	14	4	G	1789
1	11	E	1606	29	19	DC	1652	28	8	B	1698	26	16	AG	1744	25	5	F	1790
12	12	D	1607	II	I	B	1653	9	9	A	1699	7	17	F	1745	6	6	E	1791
23	13	CB	1608	22	2	A	1654	20	10	GF	1700	18	18	E	1746	17	7	DC	1792
4	14	A	1609	3	3	G	1655	1	11	E	1701	29	19	D	1747	28	8	B	1793
15	15	G	1610	14	4	FE	1656	12	12	D	1702	II	I	CB	1748	9	9	A	1794
26	16	F	1611	25	5	D	1657	23	13	C	1703	22	2	A	1749	20	10	G	1795
7	17	ED	1612	6	6	C	1658	4	14	BA	1704	3	3	G	1750	1	11	FE	1796
18	18	C	1613	17	7	B	1659	15	15	G	1705	14	4	F	1751	12	12	D	1797
29	19	B	1614	28	8	AG	1660	26	16	F	1706	25	5	ED	1752	23	13	C	1798
11	1	A	1615	9	9	F	1661	7	17	E	1707	6	6	C	1753	4	14	B	1799
22	2	GF	1616	20	10	E	1662	18	18	DC	1708	17	7	B	1754	15	15	AG	1800
3	3	E	1617	I	II	D	1663	29	19	B	1709	28	8	A	1755	26	16	F	1801
14	4	D	1618	12	12	CB	1664	11	1	A	1710	9	9	GF	1756	7	17	E	1802
25	5	C	1619	23	13	A	1665	22	2	G	1711	20	10	E	1757	18	18	D	1803
6	6	BA	1620	4	14	G	1666	3	3	FE	1712	I	II	D	1758	29	19	CB	1804
17	7	G	1621	15	15	F	1667	14	4	D	1713	12	12	C	1759	11	1	A	1805
28	8	F	1622	26	16	ED	1668	25	5	C	1714	23	13	BA	1760	22	2	G	1806
9	9	E	1623	7	17	C	1669	6	6	B	1715	4	14	G	1761	3	3	F	1807
20	10	DC	1624	18	18	B	1670	17	7	AG	1716	15	15	F	1762	14	4	ED	1808
1	11	B	1625	29	19	A	1671	28	8	F	1717	26	16	E	1763	25	5	C	1809
12	12	A	1626	II	I	GF	1672	9	9	E	1718	7	17	DC	1764	6	6	B	1810
23	13	G	1627	22	2	E	1673	20	10	D	1719	18	18	B	1765	17	7	A	1811
4	14	FE	1628	3	3	D	1674	1	11	CB	1720	29	19	A	1766	28	8	GF	1812
15	15	D	1629	14	4	C	1675	12	12	A	1721	II	I	G	1767	9	9	E	1813
26	16	C	1630	25	5	BA	1676	23	13	G	1722	22	2	FE	1768	20	10	D	1814
7	17	B	1631	6	6	G	1677	4	14	F	1723	3	3	D	1769	1	11	C	1815
18	18	AG	1632	17	7	F	1678	15	15	ED	1724	14	4	C	1770	12	12	BA	1816
29	19	F	1633	28	8	E	1679	26	16	C	1725	25	5	B	1771	23	13	G	1817
11	1	E	1634	9	9	DC	1680	7	17	B	1726	6	6	AG	1772	4	14	F	1818
22	2	D	1635	20	10	B	1681	18	18	A	1727	17	7	F	1773	15	15	E	1819
3	3	CB	1636	I	II	A	1682	29	19	GF	1728	28	8	E	1774	26	16	DC	1820
14	4	A	1637	12	12	G	1683	11	1	E	1729	9	9	D	1775	7	17	B	1821
25	5	G	1638	23	13	FE	1684	22	2	D	1730	20	10	CB	1776	18	18	A	1822
6	6	F	1639	4	14	D	1685	3	3	C	1731	I	II	A	1777	29	19	G	1823
17	7	ED	1640	15	15	C	1686	14	4	BA	1732	12	12	G	1778	11	1	FE	1824
28	8	C	1641	26	16	B	1687	25	5	G	1733	23	13	F	1779	22	2	D	1825
9	9	B	1642	7	17	AG	1688	6	6	F	1734	4	14	ED	1780	3	3	C	1826
20	10	A	1643	18	18	F	1689	17	7	E	1735	15	15	C	1781	14	4	B	1827
1	11	GF	1644	29	19	E	1690	28	8	DC	1736	26	16	B	1782	25	5	AG	1828
12	12	E	1645	II	I	D	1691	9	9	B	1737	7	17	A	1783	6	6	F	1829

[illegible] 5 tables [illegible] y^e Epact GN dom leter & y^e year of y^e lord [illegible] 1660 -- to -- 1829

EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD	EP	GN	DL	AD
26	5	FE	1600	23	13	D	1646	22	2	CB	1692	20	10	A	1738	18	18	GF	1784
6	6	D	1601	4	14	C	1647	3	3	A	1693	1	11	G	1739	29	19	E	1785
17	7	C	1602	15	15	BA	1648	14	4	G	1694	12	12	FE	1740	11	1	D	1786
28	8	B	1603	26	16	G	1649	25	5	F	1695	23	13	D	1741	22	2	C	1787
9	9	AG	1604	7	17	F	1650	6	6	ED	1696	4	14	C	1742	3	3	BA	1788
20	10	F	1605	18	18	E	1651	17	7	C	1697	15	15	B	1743	14	4	G	1789
1	11	E	1606	29	19	DC	1652	28	8	B	1698	26	16	AG	1744	25	5	F	1790
12	12	D	1607	11	1	B	1653	9	9	A	1699	7	17	F	1745	6	6	E	1791
23	13	CB	1608	22	2	A	1654	20	10	GF	1700	18	18	E	1746	17	7	DC	1792
4	14	A	1609	3	3	G	1655	1	11	E	1701	29	19	D	1747	28	8	B	1793
15	15	G	1610	14	4	FE	1656	12	12	D	1702	11	1	CB	1748	9	9	A	1794
26	16	F	1611	25	5	D	1657	23	13	C	1703	22	2	A	1749	20	10	G	1795
7	17	ED	1612	6	6	C	1658	4	14	BA	1704	3	3	G	1750	1	11	FE	1796
18	18	C	1613	17	7	B	1659	15	15	G	1705	14	4	F	1751	12	12	D	1797
29	19	B	1614	28	8	AG	1660	26	16	F	1706	25	5	ED	1752	23	13	C	1798
11	1	A	1615	9	9	F	1661	7	17	E	1707	6	6	C	1753	4	14	B	1799
22	2	GF	1616	20	10	E	1662	18	18	DC	1708	17	7	B	1754	15	15	AG	1800
3	3	E	1617	1	11	D	1663	29	19	B	1709	28	8	A	1755	26	16	F	1801
14	4	D	1618	12	12	CB	1664	11	1	A	1710	9	9	GF	1756	7	17	E	1802
25	5	C	1619	23	13	A	1665	22	2	G	1711	20	10	E	1757	18	18	D	1803
6	6	BA	1620	4	14	G	1666	3	3	FE	1712	1	11	D	1758	29	19	CB	1804
17	7	G	1621	15	15	F	1667	14	4	D	1713	12	12	C	1759	11	1	A	1805
28	8	F	1622	26	16	ED	1668	25	5	C	1714	23	13	BA	1760	22	2	G	1806
9	9	E	1623	7	17	C	1669	6	6	B	1715	4	14	G	1761	3	3	F	1807
20	10	DC	1624	18	18	B	1670	17	7	AG	1716	15	15	F	1762	14	4	ED	1808
1	11	B	1625	29	19	A	1671	28	8	F	1717	26	16	E	1763	25	5	C	1809
12	12	A	1626	11	1	GF	1672	9	9	E	1718	7	17	DC	1764	6	6	B	1810
23	13	G	1627	22	2	E	1673	20	10	D	1719	18	18	B	1765	17	7	A	1811
4	14	FE	1628	3	3	D	1674	1	11	CB	1720	29	19	A	1766	28	8	GF	1812
15	15	D	1629	14	4	C	1675	12	12	A	1721	11	1	G	1767	9	9	E	1813
26	16	C	1630	25	5	BA	1676	23	13	G	1722	22	2	FE	1768	20	10	D	1814
7	17	B	1631	6	6	G	1677	4	14	F	1723	3	3	D	1769	1	11	C	1815
18	18	AG	1632	17	7	F	1678	15	15	ED	1724	14	4	C	1770	12	12	BA	1816
29	19	F	1633	28	8	E	1679	26	16	C	1725	25	5	B	1771	23	13	G	1817
11	1	E	1634	9	9	DC	1680	7	17	B	1726	6	6	AG	1772	4	14	F	1818
22	2	D	1635	20	10	B	1681	18	18	A	1727	17	7	F	1773	15	15	E	1819
3	3	CB	1636	1	11	A	1682	29	19	GF	1728	28	[illegible]	E	1774	26	16	DC	1820
14	4	A	1637	12	12	G	1683	11	1	E	1729	9	9	D	1775	7	17	B	1821
25	5	G	1638	23	13	FE	1684	22	2	D	1730	20	10	CB	1776	18	18	A	1822
6	6	F	1639	4	14	D	1685	3	3	C	1731	1	11	A	1777	29	19	G	1823
17	7	ED	1640	15	15	C	1686	14	4	BA	1732	12	12	G	1778	11	1	FE	1824
28	8	C	1641	26	16	B	1687	25	5	G	1733	23	13	F	1779	22	2	D	1825
9	9	B	1642	7	17	AG	1688	6	6	F	1734	4	14	ED	1780	3	3	C	1826
20	10	A	1643	18	18	F	1689	17	7	E	1735	15	15	C	1781	14	4	B	1827
1	11	GF	1644	29	19	E	1690	28	8	DC	1736	26	16	B	1782	25	5	AG	1828
12	12	E	1645	11	1	D	1691	9	9	B	1737	7	17	A	1783	6	6	F	1829

these 5 tables shewetth y^e Epact G.N. Dom. leter & y^e year of y^e lord from 1360 to 159[9]

EP	GN	DL	AD
12	12	ED	1360
23	13	C	1361
4	14	B	1362
15	15	A	1363
26	16	G	1364
7	17	F	1365
18	18	ED	1366
29	19	C	1367
11	1	B	1368
22	2	A	1369
3	3	GF	1370
14	4	E	1371
25	5	D	1372
6	6	C	1373
17	7	BA	1374
28	8	G	1375
9	9	FE	1376
20	10	D	1377
1	11	C	1378
12	12	B	1379
23	13	AG	1380
4	14	F	1381
15	15	E	1382
26	16	D	1383
7	17	CB	1384
18	18	A	1385
29	19	G	1386
11	1	F	1387
22	2	ED	1388
3	3	C	1389
14	4	B	1390
25	5	A	1391
6	6	GF	1392
17	7	E	1393
28	8	D	1394
9	9	C	1395
20	10	BA	1396
1	11	G	1397
12	12	F	1398
23	13	E	1399
4	14	DC	1400
15	15	B	1401
26	16	A	1402
7	17	G	1403
18	18	FE	1404
29	19	D	1405
11	1	C	1406
22	2	B	1407

EP	GN	DL	AD
3	3	AG	1408
14	4	F	1409
25	5	E	1410
6	6	D	1411
17	7	CB	1412
28	8	A	1413
9	9	G	1414
20	10	F	1415
1	11	ED	1416
12	12	C	1417
23	13	B	1418
4	14	A	1419
15	15	GF	1420
26	16	E	1421
7	17	D	1422
18	18	C	1423
29	19	BA	1424
11	1	G	1425
22	2	F	1426
3	3	E	1427
14	4	DC	1428
25	5	B	1429
6	6	A	1430
17	7	G	1431
28	8	[illegible]	1432
9	9	D	1433
20	10	[illegible]	1434
1	11	B	1435
12	12	[illegible]	1436
23	13	E	1437
4	14	DE	1438
15	15	D	1439
26	16	CB	1440
7	17	A	1441
18	18	[illegible]	1442
29	19	F	1443
11	1	ED	1444
12	2	C	1445
23	3	[illegible]	1446
14	4	A	1447
25	5	GF	1448
6	6	E	1449
17	7	[illegible]	1450
28	8	C	1451
9	9	[illegible]	1452
20	10	G	1453
1	11	[illegible]	1444
12	12	E	1445

EP	GL. DL		AD
23	13	DC	1456
4	14	B	1457
15	15	A	1458
26	16	G	1459
7	17	FE	1460
18	18	D	1461
29	19	C	1462
11	1	B	1463
22	2	AG	1464
3	3	F	1465
14	4	E	1466
25	5	D	1467
6	6	CB	1468
17	7	A	1469
28	8	G	1470
9	9	F	1471
20	10	ED	1472
1	11	C	1473
12	12	B	1474
23	13	A	1475
4	14	GF	1476
15	15	E	1477
26	16	D	1478
7	17	C	1479
18	18	BA	1480
29	19	G	1481
11	1	F	1482
22	2	E	1483
3	3	DC	1484
14	4	B	1485
25	5	A	1486
6	6	G	1487
17	7	FE	1488
28	8	D	1489
9	9	C	1490
20	10	B	1491
1	11	AG	1492
12	12	F	1493
23	13	E	1494
4	14	D	1495
15	15	CB	1496
26	16	A	1497
7	17	G	1498
18	18	F	1499
29	19	ED	1500
11	1	C	1501
22	2	B	1502
3	3	A	1503

EP	GN	DL	AD
14	4	GF	1504
25	5	E	1505
6	6	D	1506
17	7	C	1507
28	8	BA	1508
9	9	G	1509
20	10	F	1510
1	11	E	1511
12	12	DC	1512
23	13	B	1513
4	14	A	1514
15	15	G	1515
26	16	FE	1516
7	17	D	1517
18	18	C	1518
29	19	B	1519
11	1	AG	1520
22	2	F	1521
3	3	E	1522
14	4	D	1523
25	5	CB	1524
6	6	A	1525
17	7	G	1526
28	8	F	1527
9	9	ED	1528
20	10	C	1529
1	11	B	1530
12	12	A	1531
23	13	GF	1532
4	14	E	1533
15	15	D	1534
26	16	C	1535
7	17	BA	1536
18	18	G	1537
29	19	F	1538
11	1	E	1539
22	2	DC	1540
3	3	B	1541
14	4	A	1542
25	5	G	1543
26	6	FE	1544
17	7	D	1545
28	8	C	1546
9	9	B	1547
20	10	AG	1548
1	11	F	1549
12	12	E	1550
23	13	D	1551

EP	GN	DL	AD
4	14	CB	1552
15	15	A	1553
26	16	G	1554
7	17	F	1555
18	18	ED	1556
29	19	C	1557
11	1	B	1558
22	2	A	1559
3	3	GF	1560
14	4	E	1561
25	5	D	1562
6	6	C	1563
17	7	BA	1564
28	8	G	1565
9	9	F	1566
20	10	E	1567
1	11	DC	1568
12	12	B	1569
23	13	A	1570
4	14	G	1571
15	15	FE	1572
26	16	D	1573
7	17	C	1574
18	18	B	1575
29	19	AG	1576
11	1	F	1577
22	2	E	1578
3	3	D	1579
14	4	CB	1580
25	5	A	1581
6	6	G	1582
17	7	F	1583
28	8	ED	1584
9	9	C	1585
20	10	B	1586
1	11	A	1587
12	12	GF	1588
23	13	E	1589
4	14	D	1590
15	15	C	1591
26	16	BA	1592
7	17	G	1593
18	18	F	1594
29	19	E	1595
11	1	DC	1596
22	2	B	1597
3	3	A	1598
14	4	G	1599

16		from X mas to Shrove-sunday	Shrove sunday 1st	first sunday in lent	Easter sunday	Rogation sunday	Ascension Day	Whitsunday	trinity sunday	Advent sunday	Easter term Begin	Easter term End	trinity term Begin	trinity term End
5	D	5 weekes 3 days	feb 1	feb 8	mar 22	Apr 26	Apr 30	may 10	may 17	No 29	Apr 8	may 4	may 22	June [illegible]
--	E	5 weekes 4 days	2	9	23	27	may 1	11	18	30	9	5	23	11
13	F	5 weekes 5 days	3	10	24	28	2	12	19	Dec 1	10	6	24	12
2	G	5 weekes 6 days	4	11	25	29	3	13	20	2	11	7	25	13
---	A	6 weekes	5	12	26	30	4	14	21	3	12	8	26	14
10	B	6 weekes 1 day	6	13	27	mar 1	5	15	22	No 27	13	9	27	15
--	C	6 weekes 2 days	7	14	28	2	6	16	23	28	14	10	28	16
18	D	6 weekes 3 days	8	15	29	3	7	17	24	29	15	11	29	17
7	E	6 weekes 4 days	9	16	30	4	8	18	25	30	16	12	30	18
---	F	6 weekes 5 days	10	17	31	5	9	19	26	Dec 1	17	13	31	19
15	G	6 weekes 6 days	11	18	Apr 1	6	10	20	27	2	18	14	June 1	20
4	A	7 weekes	12	19	2	7	11	21	28	3	19	15	2	21
---	B	7 weekes 1 day	13	20	3	8	12	22	29	No 27	20	16	3	22
12	C	7 weekes 2 days	14	21	4	9	13	23	30	28	21	17	4	23
1	D	7 weekes 3 days	15	22	5	10	14	24	31	29	22	18	5	24
---	E	7 weekes 4 days	16	23	6	11	15	25	June 1	30	23	19	6	25
9	F	7 weekes 5 days	17	24	7	12	16	26	2	Dec 1	24	20	7	26
---	G	7 weekes 6 days	18	25	8	13	17	27	3	2	25	21	8	27
17	A	8 weekes	19	26	9	14	18	28	4	3	26	22	9	28
6	B	8 weekes 1 day	20	27	10	15	19	29	5	No 27	27	23	10	29
--	C	8 weekes 2 days	21	28	11	16	20	30	6	28	28	24	11	30
14	D	8 weekes 3 days	22	mar 1	12	17	21	31	7	29	29	25	12	July 1
3	E	8 weekes 4 days	23	2	13	18	22	June 1	8	30	30	26	13	2
---	F	8 weekes 5 days	24	3	14	19	23	2	9	Dec 1	may 1	27	14	3
11	G	8 weekes 6 days	25	4	15	20	24	3	10	2	2	28	15	4
---	A	9 weekes	26	5	16	21	25	4	11	3	3	29	16	5
19	B	9 weekes 1 day	27	6	17	22	26	5	12	No 27	4	30	17	6
8	C	9 weekes 2 days	28	7	18	23	27	6	13	28	5	31	18	7
	D	9 weekes 3 days	mar 1	8	19	24	28	7	14	29	6	June 1	19	8
	E	9 weekes 4 days	2	9	20	25	29	8	15	30	7	2	20	9
	F	9 weekes 5 days	3	10	21	26	30	9	16	Dec 1	8	3	21	10
	G	9 weekes 6 days	4	11	22	27	31	10	17	2	9	4	22	11
	A	10 weekes	5	12	23	28	June 1	11	18	3	10	5	23	12
	B	10 weekes 1 day	6	13	24	29	2	12	19	No 27	11	6	24	13
	C	10 weekes 2 days	7	14	25	30	3	13	20	28	12	7	25	14

		Shraue Sunday	first Sunday in Lent	Easter Sunday	Rogation Sunday	Ascension Day	White Sunday	trinity Sunday	Aduent Sunday	Easter term Begin	Easter term End	trinity term Begin	trinity term End
5	3	feb 1	feb 8	mar 22	Apr 26	Apr 30	may 10	may 17	No 29	Apr 8	may 4	may 22	June 10
5	4	2	9	23	27	may 1	11	18	30	9	5	23	11
5	4	3	10	24	28	2	12	19	Dec 1	10	6	24	12
5	6	4	11	25	29	3	13	20	2	11	7	25	13
6	0	5	12	26	30	4	14	21	3	12	8	26	14
6	1	6	13	27	may 1	5	15	22	No 27	13	9	27	15
6	2	7	14	28	2	6	16	23	28	14	10	28	16
6	3	8	15	29	3	7	17	24	29	15	11	29	17
6	4	9	16	30	4	8	18	25	30	16	12	30	18
6	5	10	17	31	5	9	19	26	Dec 1	17	13	31	19
6	6	11	18	Apr 1	6	10	20	27	2	18	14	June 1	20
7	0	12	19	2	7	11	21	28	3	19	15	2	21
7	1	13	20	3	8	12	22	29	No 27	20	16	3	22
7	2	14	21	4	9	13	23	30	28	21	17	4	23
7	3	15	22	5	10	14	24	31	29	22	18	5	24
7	4	16	23	6	11	15	25	June 1	30	23	19	6	25
7	5	17	24	7	12	16	26	2	Dec 1	24	20	7	26
7	6	18	25	8	13	17	27	3	2	25	21	8	27
8	0	19	26	9	14	18	28	4	3	26	22	9	28
8	[illegible]	20	27	10	15	19	29	5	No 27	27	23	10	29
8	2	21	28	11	16	20	30	6	28	28	24	11	30
8	3	22	mar 1	12	17	21	31	7	29	29	25	12	July 1
8	4	23	2	13	18	22	June 1	8	30	30	26	13	2
8	5	24	3	14	19	23	2	9	Dec 1	may 1	27	14	3
8	6	25	4	15	20	24	3	10	2	2	28	15	4
9	0	26	5	16	21	25	4	11	3	3	29	16	5
9	1	27	6	17	22	26	5	12	No 27	4	30	17	6
9	2	28	7	18	23	27	6	13	28	5	31	18	7
9	3	mar 1	8	19	24	28	7	14	29	6	June 1	19	8
9	4	2	9	20	25	29	8	15	30	7	2	20	9
9	5	3	10	21	26	30	9	16	Dec 1	8	3	21	10
9	6	4	11	22	27	31	10	17	2	9	4	22	11
10	0	5	12	23	28	June 1	11	18	3	10	5	23	12
10	1	6	13	24	29	2	12	19	No 27	11	6	24	13
10	2	7	14	25	30	3	13	20	28	12	7	25	14

A	B	C	D	E	F	G	G
0	1	2	3	4	5	6	N
8	8	8	8	7	7	7	1
6	8	8	6	6	6	6	2
9	8	8	8	8	8	8	3
8	7	7	7	7	7	7	4
6	6	6	6	5	5	5	5
9	9	8	8	8	8	8	6
7	7	7	7	7	6	6	7
10	10	10	9	9	9	9	8
8	8	8	8	8	8	7	9
7	7	6	6	6	6	6	10
9	9	9	9	9	9	9	11
8	8	8	7	7	7	7	12
6	6	6	6	6	6	6	13
9	9	9	9	8	8	6	14
7	7	7	7	7	7	7	15
6	6	6	5	5	5	5	16
9	8	8	8	8	8	[illegible]	17
7	7	7	7	7	6	[illegible]	18

this table shewethe what sign ye moon is in or shall bee for euer --- & what part of mans Body every sign doth Govern

months of ye years	Golden Number	day of ye Month																											sign	part
feb-No	3	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2		head
March		2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	♈	& fac
	14	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4		Nec
Decem	6	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	♉	& throa
		5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6		arm &
Aprill	17	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	♊	& han
	9	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	♋	Brea
May	I	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9		&
		9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10		stoma
	12	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	♌	Hear
	4	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12		& bac
June		12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	♍	Bow
	15	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	14		& Belly
July	7	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16	15	♎	Rey
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17	16		& Loyn
	18	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	17		
	10	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19	18	♏	secre
August	2	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	19		
		19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21	20	♐	thigh
	13	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	21		
	5	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23	22	♑	Knee
Septem		22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	23		
	16	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25	24	♒	Leggs
Jan-oct	8	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26	25		
		25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	26		
	19	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I	27	♓	feet
	11	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	I		

There is a Line Given Whose Length is 100. to Divided into two Differ Segments in Such a Manner yt ye Square of ye Greatr May be Equal to ye Rectangle Made by ye Whole Line & ye Lesser Segment

a ; e

a = the Greatr
e = ye Lesser Segmt.
s = ye Sum.

Then $a+e=s$

$aa=es$

but it is Impossible to answer ys by Numbers only by Geometry

$\frac{aa}{s}=e$

$\frac{aa}{s}=s-a$

$aa=ss-sa$

$aa+sa=ss$ Theorem

Then $a=\sqrt{:\square:\frac{s}{2}:+ss:}-\frac{s}{2}$

Williams Method of Solving

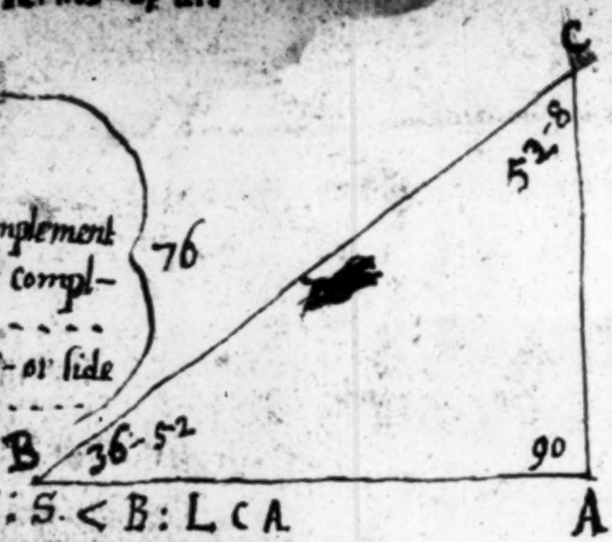
But wards Method of Solving ye adfected Equation is thus

$a=\sqrt{ss+\frac{ss}{4}}:-\frac{s}{2}$

pag- 75- & 76- terms- of art-

S- for- sine
T- for- tangent
: - for- to
S. C- for- sine complement
T. C- for- tangent compl-
:: - for - so is - - - -
L - for- latus- or side
∠ - for - angle - - - -

76

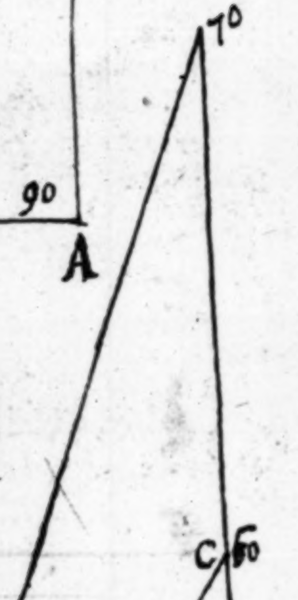


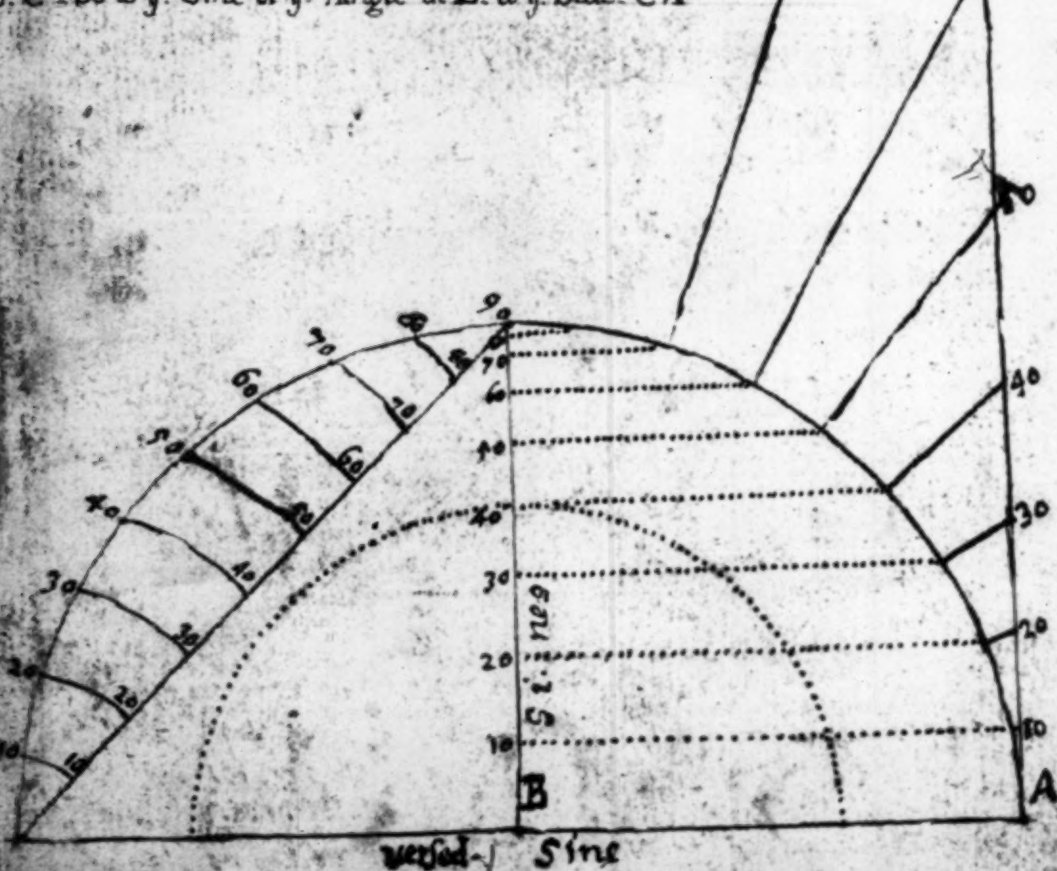
As- s < A : L. B.C :: S. < B : L C A

which is thuse read

as yͤ sine of yͤ angle at A is in proportion to yͤ side B C — so is yͤ sine of yͤ Angle at B to yͤ side C A

As yͤ Sine of yͤ Angle at A is in proportion to yͤ Side B.C - So is yͤ Sine of yͤ Angle at B. to yͤ Side C A





mar	1	8	15	22	29	No
Aug	2	9	16	23	30	Aug
may	3	10	17	24	31	Ian
Oct	4	11	18	25		Oct
Iuly	5	12	19	26		Apr
Sep	6	13	20	27		Dec
Iune	7	14	21	28		feb

♈	♍	♊	♏	♌	♎	♋
♐	♍	♒	♏	♉	♑	♓
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

9	1	8	15	22	29	1
6	2	9	16	23	30	6
11	3	10	17	24	31	3
8	4	11	18	25		8
2	5	12	19	26		5
10	6	13	20	27		7
4	7	14	21	28		12

1	6	3	8	5	7	4
9	6	11	8	2	10	12
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

1	1	8	☉	22	29	9
6	2	9	☽	23	30	6
3	3	10	♂	24	31	11
8	4	11	☿	25		8
5	5	12	♃	26		2
7	6	13	♀	27		10
12	7	14	♄	28		4

♈	1	8	15	22	29	♐
♍	2	9	16	23	30	♍
♒	3	10	17	24	31	♊
♏	4	11	18	25		♏
♌	5	12	19	26		♉
♎	6	13	20	27		♑
♓	7	14	21	28		♋

THese are to give no[illegible], That a person that hath been abroad these five years, is lately returned, and dwelleth at the Angel in *Salisbury*-Court, within 2 or 3 doors of *Sampfords* Coffee-house, who professeth as followeth, viz.

First, himself writing all the usual hands of *England*, doth undertake to teach to Write, as well in one Month or six Weeks, as any person that hath made a twelve Months dayly Practice. His rules and directions so facil, that persons of twelve or fourteen years of Age, are as capable as persons of greater Maturity, and such Ladies and Gentlewomen as are not free to come to him, he is willing to wait on them himself. He takes Faces in little, and teacheth the same, and to Draw by infallible Rules with Pencil, by president in a month, to as much Truth, Skill, and Judgment, as any that hath made a two years dayly Practice; although they never handled a Pencil or Pen before in their life time. He Ingraves any manner of writing upon Copper, for Printing in Paper or Parchment, or any Fancies upon Plate; Also he Ingraves Steel Seals, Silver Seals, cuts Cornelians, and graves all Merchants, Drapers, Clothiers, Stamps and Touches for Goldsmiths, Pewterers, Potters, Glass-houses, and Brasiers, &c. and whatever else is omitted, he undertakes, and if not perform the same without fault, offers his service free. He designs a Cipher or Figure of any Gentleman or Gentlewomans name, in that interim of time, as any person can write it at length, therein he offers his service free to any who shall give themselves the trouble to come to him: He hath several sorts of Chymical Spirits, and Ink, which are of great use, one Spirit reviving any old writing, almost or quite invisible, washing it over, it becomes as legible as when first writ, another that penetrates through twenty individual Sheets, on one time writing on one, you at the same time write on twenty more or less, another that takes off any superfluous writing or blot, without scratching with a Pen-knife. He hath a prepared Paper, that let any Ladies write with fair water, it presently becomes as black as the blackest Ink. And many other useful Secrets and Arts, too much to express here. Whoever is pleased to give themselves the trouble to come to him, will assuredly not repent their time so spent. He hath the sharpest way of Casting, as ever was found out, where every curious fancy may please it self, and any choice experiment may be made in Chymistry.

THese are to give no..., That a person that hath been abroad these five years, is lately returned, and dwelleth at the Angel in *Salisbury*-Court, within 2 or 3 doors of *Sampfords* Coffee-house, who professeth as followeth, *viz.*

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EFFIGIES AUTHORIS.

PANORGANON:

OR, A

Universal Instrument,

PERFORMING

All such Conclusions *Geometrical* and *Astronomical* as are usually wrought by the *Globes*, *Spheres*, *Sectors*, *Quadrants*, *Planispheres*, or other the like *Instruments*, yet in being; with Ease and Exactness.

Some Uses whereof are exemplified in the solution of such Problems as are of frequent use in the practise of

Geometry	*Geography*
Astronomy	*Trigonometry*
Dialling	*Projection*, &c.

By *William Leybourn*, Philom.

LONDON,

Printed for *William Birch*, at the Sign of the Bible at the corner of the *Poultry* and *Bucklersbury* at the lower end of *Cheapside*, 1672.

HONORATISSIMO D^{no}

D^{no} **HENRICO**, Marchioni

DORCHESTRIENSI:

COMITI de *KINGSTON*, VICE-COMITI

de *NEWARK*, & *BARONI*

PEIRPONT, & *MAUNVERS*,

MATHEMATICARUM ARTIUM

PATRONO atq; FAUTORI SUMMO;

Gulielmus Leybourn

LUCUBRATIONES

SUAS

PRACTICO-MATHEMATICAS,

Hocq;

PANORGANON

NOVAM

DEBILA CUM HUMILITATIS.

D. D.D.

HONORATISSIMO D^no

D^no HENRICO Marchioni

DORCHESTRIENSI:

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MATHEMATICARUM ARTIUM

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RECREATIONES

SUAS

PRACTICO-MATHEMATICAS,

[illegible]

[illegible]

NOVAS

DEBITA CUM HUMILITATE,

D.D.D.

TO THE

READER

IF I should here make mention of the several Instruments that have, from time to time, by several learned and ingenious men, been invented for the finding of the Hour, Azimuth, and other usual and necessary Astronomical and Geometrical Problems, I should exceed the bounds of a Preface. Wherefore (omitting to say any thing of those invented and published by Orontius, Stoflerus, Clarius, &c.) I shall only say somthing of that which hath hitherto received best acceptance, namely, that of Mr Gunter, which (though it be not an exact Projection of the Sphere) exceedeth any of the forementioned, yet that also is deficient, in respect it is particular for some one Latitude, and the Hour and Azimuth Lines (in all Latitudes) do occupie the most part of the whole surface of the Quadrant, and (in some Latitudes) they cannot both be inscribed (without confusion) upon the same side of the Instrument.

The Quadrantal part of the Instrument here offered to thee, is quitted of both the forementioned incumberances, and hath many other conveniencies: For

(1.) It is a perfect Projection of the Sphere, it being a part of the ANALEMA.

(2.

(2) *It may be made* Universal, *for upon it you may inscribe as many Latitudes as you please; one Line in each Latitude, serving to find both the Hour and Azimuth; and some other Problems besides (of good use) may be resolved by the same Line also: As by what is thereby performed in the Second* Part *of this Treatise may appear: For all the most usual* Problems *of the* Sphere; *the* Requisites *belonging to all the most usual sorts of* Sun-Dials: *And the* Hour, Azimuth, Amplitude, *&c: (not only of the* Sun, *but of the* Stars *also) may be found with facility and exactness: and if the* Instrument *be made but of* 8 *or* 9 *inches Radius, it shall give the* Hour *to a* minute, *and the* Azimuth *to less than* half a degree, *and that without the help of a* Bead *upon the* String *thereof, which upon the least stretching or shrinking of the Thred, altereth the Position thereof, and rendreth the work performed thereby imperfect.*

Now for the manner of working *the several* Problems *upon the* Instrument, *the lines thereof being thus disposed, within the confines of a* Quadrant, *I do confess I gained by being possessed of some few Precepts written by Mr.* Samuel Foster, *sometime* Astronomical Professor *in* Gresham Colledge, *for the use of a* Quadrant *for himself made in* Anno 1644. *which Quadrant, and the Precepts concerning the uses thereof, have been hitherto most earnestly desired and enquired after. And thus setting aside, (or accumulating to my self) any thing that may be termed* Plagiarie, *I do declare against; and thus much* Reader *I can freely say concerning the* Quadrantal part *of the* Instrument, *although I have added several Lines of my own thereunto.*

Now

To the Reader.

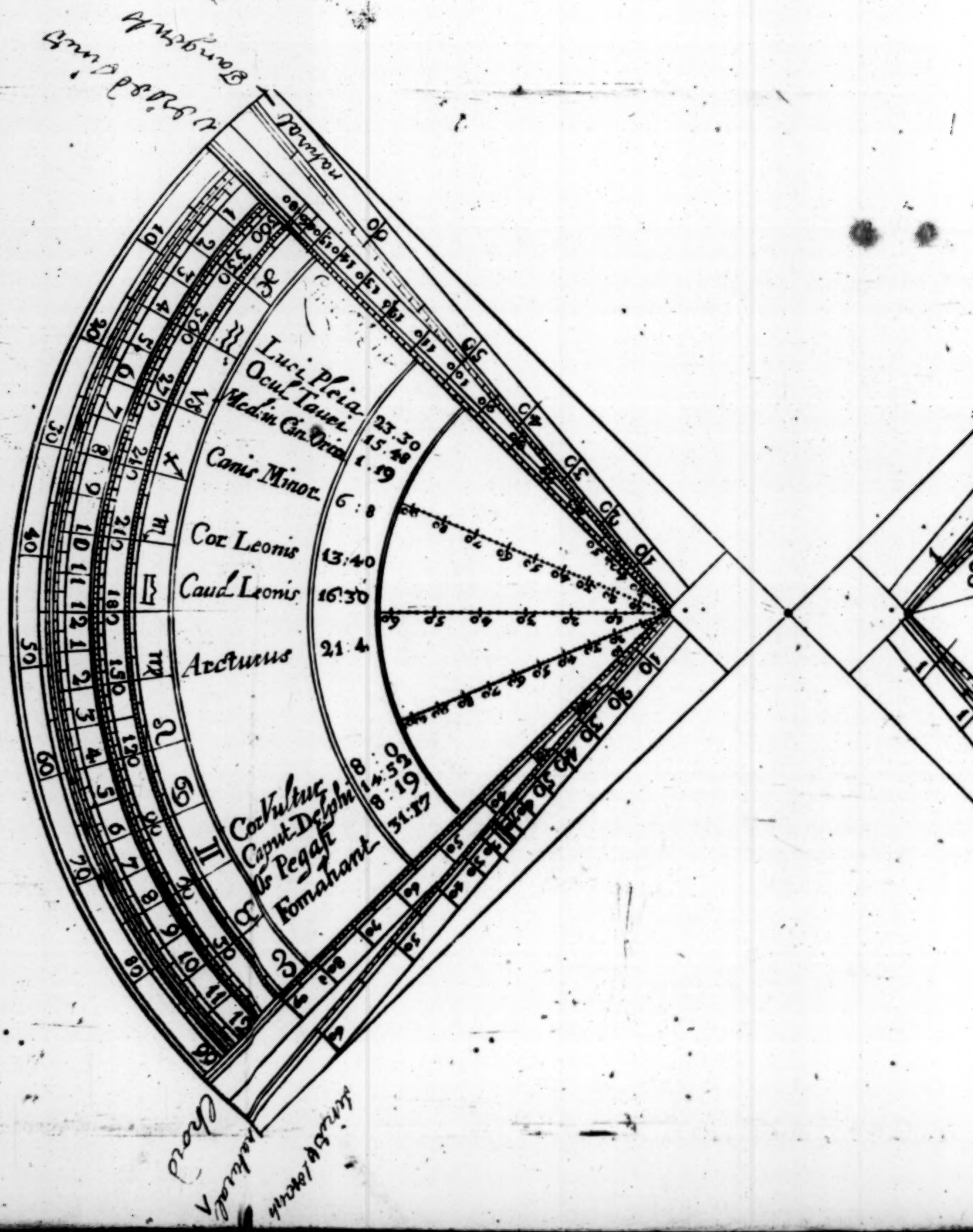
Now for the Wings *of the* Instrument, *they may be adorned* (Reader) *with what* Feathers *you please I have made choise of such as you see in the* Scheme *of the* Instrument *before the Book annexed, as being the most useful and necessary, and as well disposed, as any I have yet seen: And if the two Rules delivered in the Section of the First Part of this* Treatise *be rightly understood, any* Canons, proportions, *or* Analogies, *in* Equal Parts, Sines, Tangents, *or* Secants *single or mixed, which you find in the Works of* Mr. Gunter, Mr. Oughtred, Mr. Foster, Mr. Wingate, Mr. Collins, *or other of my own Works, or of any other Author, you may easily (by observing the two* Rules *delivered in the forementioned* Section) *apply to, and perform by this Instrument. And for the manner of* working *upon* proportionable Lines, *by one* Line, *of a kind, the before-mentioned* Mr. Foster *was the first that in the* English Tongue *ever published any thing concerning it, as in his alteration of the* Sector, *now printed with* Mr. Gunters *Works, doth appear. And the Instrument thus fitted I commend to thee, wishing thee much profit and pleasure in the use of it.*

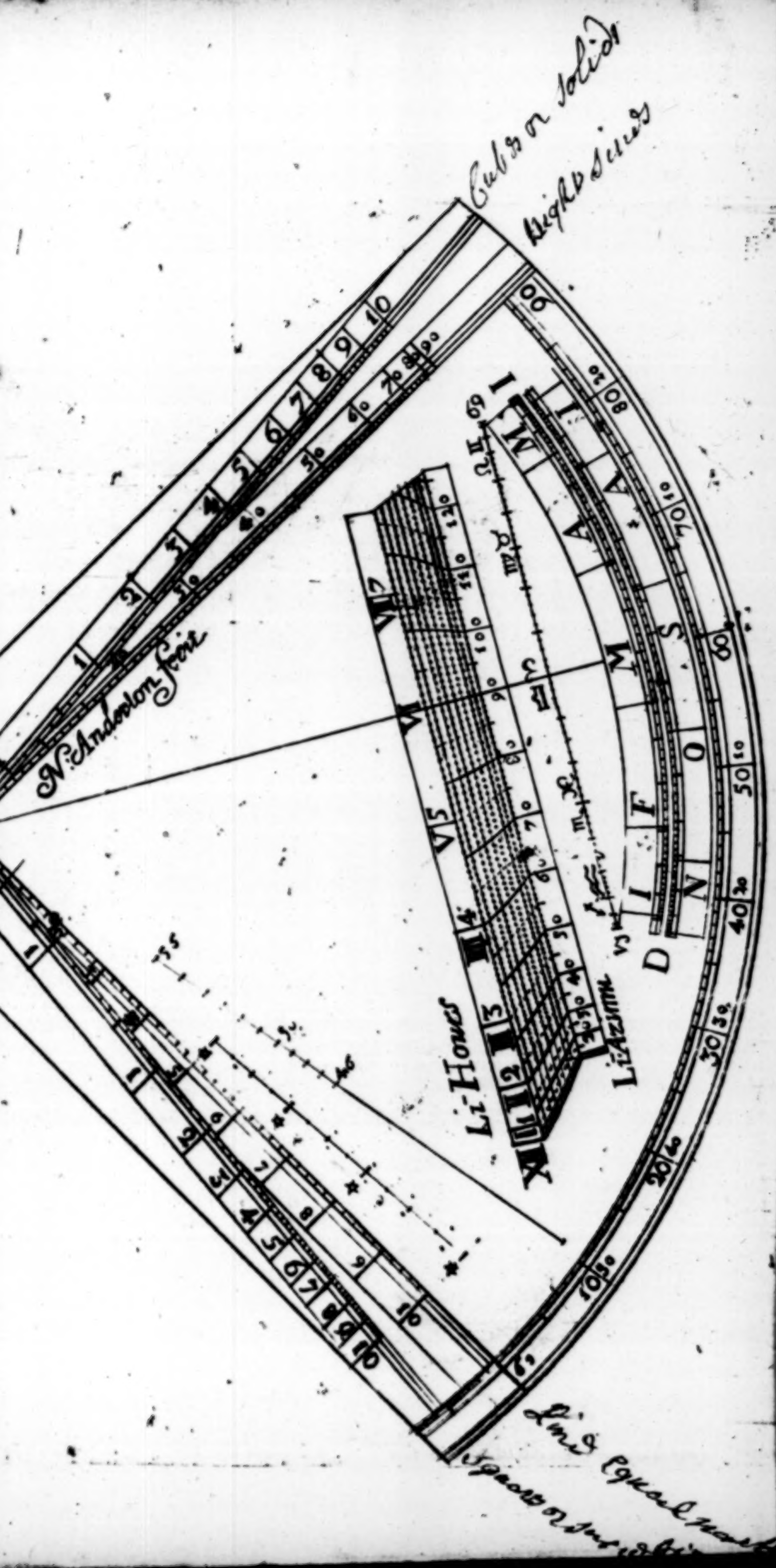
Vale.

Advertisement.

THis Instrument, or any other Mathematical Instrument, is exactly made either in Silver, Brass, or Wood, by Mr. *Walter Hayes*, at the *Cross-Daggers* in *Moore-Fields*, next Door to the *Popes Head* Tavern; where they may have all sorts of Maps, Globes, Sea-*Plats*, Carpenters Rules, Post and Pocket-Dials for any Latitude, Steel Letters, Figures, Sines, Planets, or Aspects, at reasonable Rates.

the Cord
Take of sixty degrees all ways
to describe a Circle


Luci Pleia 23:30
Ocul Tauri 15:48
Med. in Cin. Orio 1:19
Canis Minor 6:8
Cor Leonis 13:40
Caud. Leonis 16:30
Arcturus 21:4
Cor Vultur 8:0
Caput Delphi 14:53
Ar Pegasi 8:19
Fomahant 31:17


N: Anderson fecit
Li: Houres
Li: Azimuth
Cubes or solids
Right sines

PANORGANON.

The First Part.

CONTAINING

The Deſcription, Conſtruction and Uſe of the *INSTRUMENT* in general.

SECT. I.

Of the Circle, Scales and Lines upon the Inſtrument, their Deſcription and Conſtruction.

THe Inſtrument differeth not much from a *Quadrant*, only the ſides thereof are made ſomewhat broader; and the Arch comprehended between them is an exact *Quadrant* containing 90 d. The two broad ſides (for diſtinction) I call the *Wings*; and the *Quadrant*, contained between them,

them,

them, I call the *Quadrantal part of the Instrument.*

The *Wings* of the Instrument must be made of such a competent breadth, as either of them may be capable to receive two Lines at the least to issue from the Center, without incumbring one another; by this means, eight Scales may be inscribed upon the four sides of the two Wings, upon which any man may place such as may best sute with his Fancy or Occasions; and the two Wings of the Instrument thus disposed, having a Quadrant between them, exactly representeth a *Sector* opened to a right Angle; and for this reason, I have placed upon them these Lines, *viz.* upon one Wing,

{1. *Equal Parts,*
{2. *Squares* or *Superficies.*

And upon the Wing opposite thereunto,

{3. Right *Sines.*
{4. *Cubes* or *Solids.*

These four Scales are placed upon the two Wings on the foreside of the Instrument: On the two Wings on the backside are

{5. Natural *Tangents.*
{6. *Versed Sines.*

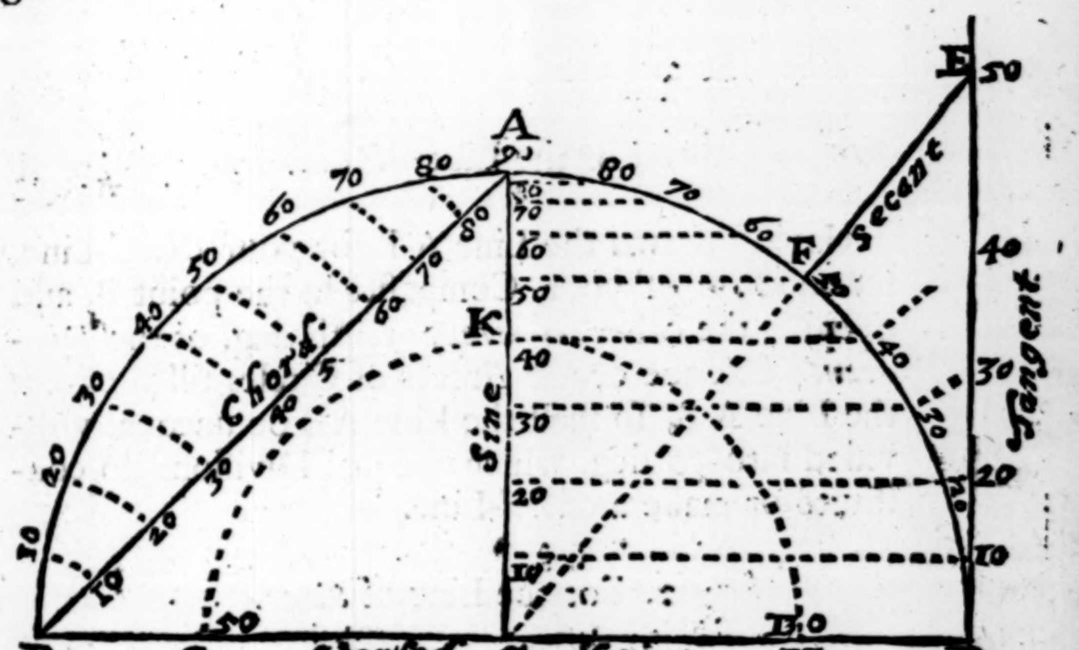
And opposite unto them,

{7. Natural *Sines* and *Secants.*
{8. *Chords.*

These are such Lines as I conceived most useful; though divers others might be inserted: And for the the construction of them, and inserting of them orderly

derly on the Instrument, it is so well known to all that are Makers of Mathematical Instruments, that I shall say nothing of that in this place; only, in the making of the Instrument, let them be sure to make the *Sines*, *Tangents*, and *Versed Sines*, to the same *Radius*. And it were not amiss, if that in some convenient place of the Instrument (as there may be found places enough) from the Center, a Scale of *equal parts*, a *Tangent* of 45 deg. numbered to 90. (commonly called an *half Tangent*) and a Scale of *Chords* also, were inserted to the same *Radius*, as the *Sines*, *Tangents* and *Secants* are, which will be of excellent use in projection of the Sphear, *&c.*

Now for the sakes of such as are ignorant of the construction of these Scales, I shall adde this Figure:



Wherein let the Line C A be the *Semidiameter*, or *Radius* of any Circle, as here it is of this Semicircle B A D.

The Semicircle being deſcribed, divide it into two equal parts or Quadrants by the perpendicular Line C A; then divide each of the Quadrants B A and A D into 90 equal parts or degrees, as in the Figure is done, to every tenth deg.

This done, your Scheme is prepared for the dividing of your Scales of *Sines*, *Tangents*, *Secants*, *Chords* and *Verſed Sines*; for,

The Line { C D is a Line of *Sine*.
D E is a *Tangent* Line.
C E is a *Secant*.
A B is a *Chord*, and
B D is a Line of *Verſed Sines*. }

And the manner how to divide them followeth.

1. For the Line of *Chords*.

Having drawn the Line A B for your *Chord*-Line, ſet one foot of your Compaſſes in the point B, and opening the other to every tenth deg. of the *Quadrant*, deſcribe occult Arcees of Circles till they cut the Line A B, ſo ſhall the Line A B be unequally divided into 90 deg. which unequal Diviſions do conſtitute or make a *Chord*-Line.

2. For the Line of *Sines*.

From every degree of the *Quadrant* A D, draw occult right Lines, all parallel to the Line C D, till they

they intersect or cut the Line A C, so shall these occult Lines divide the Line A C into 90 unequal parts or degrees, which makes the Scale of *Sines*.

3. For the Line of *Tangents*.

Upon the point D, erect a Perpendicular D E, and through every degree of the *Quadrant* A D, draw right Lines from the Center, till they cut the perpendicular Line D E, dividing that into unequal parts, called *Tangents*.

4. For the *Secants*.

A right Line drawn from the Center of the Circle C, through any degree of the *Quadrant* A D, till it meet with the *Tangent* Line, is called the *Secant* of that degree through which it cutteth in the *Quadrant*. As in the Figure, the right Line C E, passing through 50 deg. of the *Quadrant* A D, till it cut the *Tangent-Line* in E, is the *Secant* of 50 deg.

5. For the *Versed Sines*.

Tne Line of *Versed Sines* is no other than two Scales of Sines; wherefore, setting one foot of the Compasses in the point or Center C, describe occult Semicircles through every degree of the Scale of *Sines* A C, as the Semicircle G K H drawn through 40 deg. of the Line of *Sines*, giveth the point of 50 deg. of the *Versed Sines* at G, and of 130 d. at the point H, so the whole Line B D is a Scale of *Versed Sines*, beginning at 00 d. at B, 90 d. at C, and ending at 180 d. at E. And

And this may ſerve for the *Definition* and *Geometrical conſtruction* of theſe Lines; and the like might have been done for the Lines of *Squares* and *Cubes*; but the beſt way to divide the Scales of *Sines*, *Tangents*, *Secants* and *Chords*, is from the Tables of Natural *Sines*, *Tangents* and *Secants*; and the Lines of *Squares* and *Cubes* are beſt divided from Tables of the *Square* and *Cube Roots*. The manner how to apply thoſe Tables to the transferring of the Lines upon the Inſtrument, is ſo well known, and the Tables themſelv es in every mans hands, that it were needleſs here, either to inſert the Tables, or ſay any thing more concerning the Lines on the Wings of the Inſtrument, only in the ſpare places between the general Lines, other Lines more particular (as of *Equated Bodies*, *Segments* of *Circles* or *Sphears*, *Metals*, *Inſcribed Bodies*, of *Quadrature*, &c.) may be inſerted, in the void places, between the general Lines before-mentioned: And if the Wings of the Inſtrument be made broad enough, more Lines than two upon one Wing may be made to iſſue from the Center; but the eight forementioned being the moſt uſeful and neceſſary, I ſhall only exemplifie in them; any other Lines whatſoever, that are deſcribed upon any *Sector* whatſoever, may be inſerted into this, and their uſes alſo applied hereunto. And now ſhall follow,

The Deſcription of ſuch Lines as are inſcribed on the Quadrantal Part of the Inſtrument.

The Quadrantal part of the Inſtrument conſiſteth of two ſides, *viz.* The *Foreſide* and the *Backſide*: The *Foreſide* is ſome part of a Projection of the Sphear *in plano*,

plano, and ſome other Scales; and the *Back-ſide* conſiſts only of ſeveral concentrick Circles, in which are placed ſeveral circular Scales, principally relating to the Motions of the *Fixed Stars.*

I. *The Deſcription of the Lines, and the Conſtruction of the Foreſide of the Inſtrument.*

Between the two Wings of the Inſtrument is left an exact *Quadrant*, the Limb whereof is divided into 90 equal degrees, and ſubdivided into parts, according to the largeneſs of the Inſtrument, and numbred by 10, 20, 30, *&c.* (from the left hand towards the right) to 90 deg. after the uſual manner. And within the Superficies, is deſcribed a part of that projection of the Sphear, which is uſually known by the name of the *ANALEMMA*; and the manner how to draw this Projection, for any Latitude or Latitudes, is as followeth.

Firſt, Leaving ſome convenient ſpace for the deſcribing of two Circular Arches, for the inſcription of the *Moneths*, and *Dayes* of the *Moneths*, deſcribe an occult arch of a Circle, as A B; and laying a Ruler from O, the Center of the Inſtrument, to 60 deg. (or to any other more convenient number of deg. which may be more ſutable to the Latitude of the place for which you make your Inſtrument, as 60 d. is moſt ſutable for thoſe middle Latitudes which I have here made choice of) draw a right Line O C, which line may be called *The Line of the Suns Altitude*, or *Line* of 60, and may be divided from C towards O, as a Line of Sines is divided.

Secondly, Conſider what Latitude or Latitudes you would

would insert into your Instrument (as I have inserted in this Instrument, in the Figure, all the Latitudes from 46 deg. to 54 deg. which will serve all the principal Places in *Europe*, and more might be inserted.) But for Instance; Suppose I would insert the Latitude of *London* 51 deg. 30 m. count the Complement thereof 38 deg. 30 min. upon the Limb of the *Quadrant* from 60 deg. towards the left hand, and from the Center of the *Quadrant*; thereto lay a Ruler, so shall it cut the Arch formerly drawn in D, and a right Line drawn from D, perpendicular to the Line of the Suns Altitude, or Line of 60, as the Line D E, (which Line D E must be continued so far beyond the Line of 60, till it meet with a Line drawn from the Center O, to 23 d. 30 m. counted in the Limb from 60 d. towards the right hand) and this shall be the Line representing the Latitude of 51 deg. 30 m. And the like may be done for any other Latitude.

Thirdly, For the division of this Line of the Latitude of *London*, (or of any other deg. of Latitude) it is to be divided, in all respects, as a Line of Sines is divided, beginning at the Line of 60, and numbering of it, as in the Figure; that is to say, from the left hand towards the right, by 10, 20, 30, *&c.* to 120, and farther, or not so far, as the Latitude of the place shall require, for the counting of the *Azimuths*: And the same Divisions will serve for the dividing of the Hours, which are numbered from the left hand towards the right, by 1, 2, 3, 4, 5, 6, 7, 8, representing the hours of the Afternoon; and back again by IV, V, VI, VII, VIII, IX, X, XI, XII, representing the hours of the Forenoon; each hour being sub-divided into 15 unequal parts or degrees; each part

degree containing 4 minutes of time : Or, ur may be divided into Halves, Quarters and rters, according to the mind of him that is to And if there be ſeveral Latitudes put into one ent, as here is from 46 to 54 deg. of Latitude, were neceſſary (at the two extream Latitudes) Marginal Lines, one above the leſſer Latind the other beneath the greater Latitude, the erein to ſet the numbers of the hours, which called the *Line of Hours*, and the other, wheret the numbers of the *Azimuths*, and may be he *Azimuth Line*.

thly, Count 23 deg. 30 min. (the Suns greatination) from 60 deg. in the Limb, on either ereof, and from the Center O, thereto lay a which ſhall cut the circular Arch formerly on the right hand of 60, at the point ♋, and left hand of 60, at the point ♑ ſo a right Line from theſe two points *Cancer* and *Capricorn*, called the *Zodiack*; (and this *Zodiack* is alſo for the Latitude of 23 deg. 30 min, though generally to be uſed with all other Latitudes, he following Uſes will appear.)—— For the di of this *Zodiack-Line*, it is to be divided in all ts as a Line of Sines is divided; but the num thereof is different; for it repreſenting the *k*, is divided into 12 parts, anſwerable to the es, and is numbered from the middle thereof, s the right hand.

Above the line	♈ 10 20 ♉ 10 20 ♊ 10 20
	♋
Under the line	♎ 20 10 ♍ 20 10 ♌ 20 10.

C And

would insert into your Instrument (as I have inse
in this Instrument, in the Figure, all the Latitu
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But for Instance; Suppose I would insert the L
tude of *London* 51 deg. 30 m. count the Complem
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drant from 60 deg. towards the left hand, and fr
the Center of the *Quadrant*; thereto lay a Ruler,
shall it cut the Arch formerly drawn in D, an
right Line drawn from D, perpendicular to the Line
the Suns Altitude, or Line of 60, as the Line D
(which Line D E must be continued so far beyond t
Line of 60, till it meet with a Line drawn from t
Center O, to 23 d. 30 m. counted in the Limb fro
60 d. towards the right hand) and this shall be th
Line representing the Latitude of 51 deg. 30 m. An
the like may be done for any other Latitude.

Thirdly, For the division of this Line of the Latitude of *London*, (or of any other deg. of Latitude) it is to be divided, in all respects, as a Line of Sines is divided, beginning at the Line of 60, and numbering of it, as in the Figure; that is to say, from the left hand towards the right, by 10, 20, 30, *&c.* to 120, and farther, or not so far, as the Latitude of the place shall require, for the counting of the *Azimuths*: And the same Divisions will serve for the dividing of the Hours, which are numbered from the left hand towards the right, by 1, 2, 3, 4, 5, 6, 7, 8, representing the hours of the Afternoon; and back again by IV, V, VI, VII, VIII, IX, X, XI, XII, representing the hours of the Forenoon; each hour being sub-divided into 15 unequal parts or degrees; each part

part or degree containing 4 minutes of time: Or, each hour may be divided into Halves, Quarters and half Quarters, according to the mind of him that is to uſe it. And if there be ſeveral Latitudes put into one Inſtrument, as here is from 46 to 54 deg. of Latitude, then it were neceſſary (at the two extream Latitudes) to draw Marginal Lines, one above the leſſer Latitude, and the other beneath the greater Latitude, the one, wherein to ſet the numbers of the hours, which may be called the *Line of Hours*, and the other, wherein to ſet the numbers of the *Azimuths*, and may be called the *Azimuth Line*.

Fourthly, Count 23 deg. 30 min. (the Suns greateſt declination) from 60 deg. in the Limb, on either ſide thereof, and from the Center O, thereto lay a Ruler, which ſhall cut the circular Arch formerly drawn, on the right hand of 60, at the point ♋, and on the left hand of 60, at the point ♑ ſo a right Line drawn from theſe two points *Cancer* and *Capricorn*, ſhall be called the *Zodiack*; (and this *Zodiack* is alſo the line for the Latitude of 23 deg. 30 min. though it be generally to be uſed with all other Latitudes, as in the following Uſes will appear.)—— For the dividing of this *Zodiack-Line*, it is to be divided in all reſpects as a Line of Sines is divided; but the numbering thereof is different; for it repreſenting the *Zodiack*, is divided into 12 parts, anſwerable to the 12 Signes, and is numbered from the middle thereof, towards the right hand.

Thus	Above the line	♈ 10 20 ♉ 10 20 ♊ 10 20 ♋
	Under the line	♎ 20 10 ♍ 20 10 ♌ 20 10.

And from the middle thereof towards the left hand,

Thus	Above the line	♑	10 20 ♒ 10 20 ♓ 10 20.
	Under the line		20 10 ♐ 20 10 ♏ 20 10.

Fifthly, This Scale or *Zodiack* is contained between 23 deg. 30 min. and 23 deg. 30 m. on either side of the line of 60. So that the 23 deg. 30 m. of the Limb, which lieth on the right hand, are to be counted as the 23 deg. 30 m. of the Suns *North Declination*, and the 23 deg. 30 m. on the left hand, are to be counted as the degrees of the Suns *South Declination*: and may be called the *Scale of the Suns Declination*.

Sixthly, Between the Limb of the *Quadrant*, and the Circular Arch before drawn, are described two Circles, containing the Moneths, and Dayes of each Moneth in the year, *viz*. In the uppermost is inscribed one half of the year, namely, the *Spring* and *Summer* Quarters, containing part of *December*, all *January*, *February*, *March*, *April*, *May*, and part of *June*; and the undermost contains the *Autumnal* and *Winter* Quarters; namely, part of *June*, all *July*, *August*, *September*, *October*, *November*, and part of *December*. These two Circles are called the *Circles of Moneths*, and the manner how to divide them is sufficiently known; for they may be divided by Tables of the Suns declination, from the Scales of the Suns Declination; or from Tables of the Suns place, from the *Zodiack-line*: This is so well known, and the Tables so common, both in this and other Books, that it were needless to say more concerning it.

Thus

Thus have you a Deſcription of the General Lines which are inſcribed upon the *Quadrantal part* of the foreſide of the Inſtrument: Wherein you are to obſerve, that if you are to inſert never ſo many lines of Latitudes, they muſt all of them be divided as if they were ſo many ſeveral lines of Sines; but inſerting many Latitudes together (as here I have done, for 9 or 10 ſeveral degrees of Latitude) the ſeveral Lines may be divided by Arches of *Ellipſes* (eſpecially for every 5th. degree) and the intermediate diviſions by Pricks only, which will not only be eaſie to deſcribe, but very pleaſant and ready to count by; and the hour-points of 12, and Azimuths of 00 deg. in all Latitudes, will be a perfect Circle; the Hours of ſix, and Azimuths of 90 deg. will be a ſtraight line, and all the other, Elliptical Arches; and are left to be ſo deſcribed.

Beſides theſe Lines before deſcribed, there are other Lines: As,

1. A *Line of three Hours*, placed near to one of the Wings of the Inſtrument, which is no other than a Tangent line of 45 deg. made to half the *Radius* of the Inſtrument; and may be divided by a Table of Natural Tangents, into the Degrees and Minutes belonging to the Quarters, Halves, Three Quarters, and whole Hours. It ſtandeth neer to the right wing of the Inſtrument, and is divided firſt into 3 unequal parts, marked with ***, repreſenting whole hours; then either of theſe three parts is divided into two other unequal parts, marked with little ſhort lines, thus, | | |, repreſenting half hours: And again, every of theſe parts is divided into two other unequal parts, by points only; as ------, repreſenting quarters of hours.

hours. This Scale is called the *Scale of three Hours.*

2. Besides this Line of Three Hours, there is another Line, called the *Latitude-Line*, which Line contains the numbers of the Complements of such degrees of Latitude as are inserted in the Instrument; which Line may be made to every degree of Latitude, and that in this manner:

Make the Hour or Azimuth-Scale belonging to each particular Latitude, a several *Radius*, or 1000 parts. The several points in the Latitude-line from 36 to 54, are the Natural Tangents of the Complements of those Latitudes; as the Natural Tangent 726 giveth the point of 36 deg. of Latitude in the Line of Latitudes, its Complement 54 deg. of Latit. being made the *Radius*, and the rest as in the Table following.

A Table for the dividing of the Latitude-Line.

Degr. of Latitude	Natural Tangents.	Degr. of Latitude.	Natural Tangents.
36	1 - 376	45	1 - 000
37	1 - 327	46	0 - 965
38	1 - 279	47	0 - 932
39	1 - 234	48	0 - 800
40	1 - 191	49	0 - 869
41	1 - 150	50	0 - 839
42	1 - 110	51	0 - 810
43	1 - 072	52	0 - 781
44	1 - 053	53	0 - 753
		54	0 - 726

This

This Table of Latitudes may easily be continued to any other degr. of Latitude, even from the Equinoctial to the Pole, and may be set in any spare place upon the Instrument; but best, and most readiest, near to one of the Wings. And thus have you a Description of all the Lines on the foreside of the Quadrantal part of the Instrument.

II. *The Description of the Circles on the Back side of the Quadrantal Part.*

Next, above the equal Limb of 90 degr. there is,

1. A Circle of *Right Ascensions in Time*, the whole *Quadrant* being divided into 24 equal parts, signifiing hours, and numbered from the left towards the right hand, by 1, 2, 3, 4, *&c*, to 12 in the middle; and then forward forward from the middle 12, by 1, 2, 3, *&c.* to 12 at the end; the 12 in the middle signifying 12 at Midnight.

2. There is a Circle of *Right Ascensions in Degrees and Minutes*, the *Quadrant* being divided into 360 deg. one degr. of the equal Limb being equal to some of these, it is numbered from the right hand towards the left, by 10, 20, 30, *&c.* to 360. This Circle is useful to convert Degr. and Minutes of the Equinoctial into Hours and Minutes of Time.

3. An *Eclipticк*, having at every 30th. deg. of the Circle of *Right Ascensions*, the Characters of one of the *Signs*, as at the beginning, towards the right hand, is *Aries*; 30 deg. forwarder is *Taurus*; and 30 deg. forwarder, *Gemini*, &c.

4. Above this Circle is a small Margin, having in it only the *Characters* of such *Stars* as are placed in the Instrument.

5. The

5. The *Names of those Stars*, and are inserted according to their *Right Ascensions*.

6. Above the Names, is set the *Declinations* of those Stars. And,

7. Their *Magnitudes*,

The Stars placed in the Instrument, may be any, either such as are in the Table at the end of this Book, or such others as are best known or desired by the User of the Instrument. And being there is some spare place between these Circles and the Center of the Instrument (such as desire it) may have there inserted such hour-Lines as are usually drawn upon Mr. *Gunter's* Quadrant; for that they give the Hour more readily (though not so exactly) as the Scales on the other side of the Instrument.

And thus have you a particular account of the several *Lines*, *Scales* and *Circle* inscribed upon the whole Instrument; to which also there belongeth two *Sights*, a *Thred* and *Plummet*, as is usual in all *Quadrants*. But besides the ordinary Line and Plummet, which may be made to hang excentrick to the Center of the *Quadrant*; on the backside, I would have a very fine Hair, Silk, or Wire, to go quite through the Center of the Instrument, and be fastned at either end to a piece of Brass, having a Groove in it equal to the Limb of the *Quadrant*, and in that Groove a Spring, which may at all times keep the String straight from the Center of the *Quadrant*; and being moved along, may stand fixed in any position whatsoever. This Groove may be turned aside

aside under one of the Wings of the Instrument, at any time, when you are to take the *Altitude* of the *Sun* or *Stars*; so that it may not hinder the motion or playing of the other Thred and Plummet, which is to be put on and taken off at pleasure; but the other would be constantly fixed.

And thus much shall serve for the Description; now shall follow the Uses of the Instrument.

SECT.

SECT. II.

Of the General Use of the Instrument, and the manner of working upon it.

THe Instrument being made and fitted as is before directed, the Wings thereof do exactly represent a *Sector* opened to a right Angle, and the motion of the Thred between the two Wings, do make it a *Sector* opened to any Angle less than a right Angle; by which means, all Proportions may be wrought by it, as well as by a *Sector*; and altogether as *exactly*, *easily*, and more *expeditiously* than by the *Sector*; whether the *Proportion* to be wrought, be to be performed upon one single Line, or upon two or more Lines; and whether the *Proportion* be *Direct* or *Reciprocal*.

For the manner of working upon the Instrument in general, these things are to be considered.

1. *The manner how to dispose the Terms of the Proportion:* And,
2. *The Terms being truly disposed, how to apply them to, and work them upon the Instrument.*

And for the Disposition of the Terms;

1. If the 4 Terms be all of one kind, or denomination,

nation, ſo as the firſt is to the ſecond, as the third may be to the fourth.

2. But to diſpoſe the Terms of a Proportion of different kinds, you are ſo to order them (as near as you can) that the *firſt* and the *third* may be of one kind, name, or denomination; and the *ſecond* and *fourth* Terms of another.

The Terms being diſpoſed, to know upon what Scale your work muſt be performed, when they are of different kinds;

Compare the two firſt Terms of your Proportion together, and find which of them is them is the longeſt (which you may do by meaſuring each of them upon his proper Scale) and upon that Scale which belongeth to the longeſt Term, muſt the Proportion be performed,

The Terms being diſpoſed, and the Scale upon which the Proportion is to be wrought, known; the manner of working upon the Inſtrument, will be twofold: And for the two different manners of working, obſerve theſe two *General Rules*.

If the *SECOND TERM* be

LESSER than the First,

Take the *Second Term* out of its proper Scale, and ſet that diſtance in the point of the *Firſt Term*, bringing the Thred to the neareſt diſtance. Then from the point of the *Third Term*, take the neareſt diſtance to the Thred; and this diſtance meaſured upon the Scale, from whence the *Second Term* was taken, ſhall give the *Fourth Term* required.

And this is called *LATERAL* Entrance.

GREATER than the First,

Take the *Firſt Term* out of its proper Scale, and ſet that diſtance in the point of the *Second Term*, bringing the Thred to the neareſt diſtance. Then take the *Third Term* out of its proper Scale, and (with that diſtance) move one foot of the Compaſſes gently along the Line, till the other, being turned about, may only touch the Thred; ſo ſhall the Compaſs-point reſt in the *Fourth Term* required.

And this is called *PARALLEL* Enterance.

Thus

Thus have you the wayes of working, and the difference, or diſtinction, between *Parallel* and *Lateral Enterance*; the Ground and Reaſon whereof is demonſtrated in the ſecond and fourth *Prop.* of the 6th. of *Euclide*, and needs not here be repeated; for, in this Treatiſe I do not deſign *Demonſtration*, but *Practice*. And that what is now laſt delivered, may the more evidently appear (for in the following Examples I intend to avoid Circumlocutions) I will adde a plain Scheme, with an example of each kind wrought upon it.

Example 1.

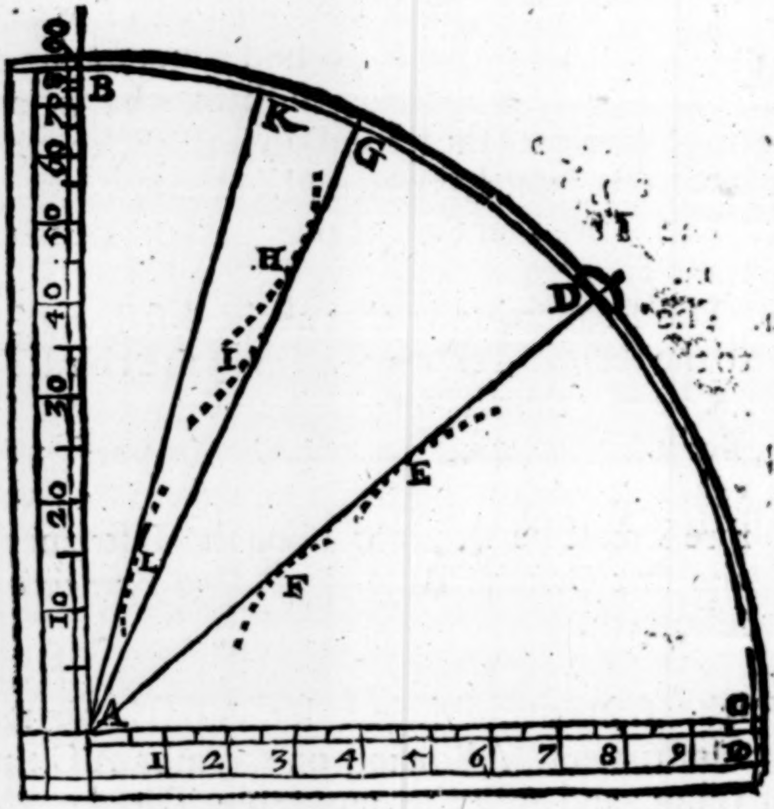
Let there be three Numbers given, *viz.* 80, 50 and 48. and let it be required to find a fourth number, which ſhall be in proportion to them, that is, as 80, (the firſt) is to 50 (the ſecond) ſo ſhall 48 (the third) be to a fourth, which is required. Here,

1. The Terms are all of one kind or denomination.
2. The Proportion is, that as the firſt Term 80, is to the ſecond Term 50, ſo muſt the third Term 48, be to a fourth Term.
3. Becauſe the ſecond Term in the Proportion (*viz.* 50) is leſs than the firſt Term (*viz.* 80) therefore it muſt be wrought upon the Inſtrument by the firſt General Rule, by *lateral Entrance*; as followeth.

In the Scheme following, let ABCD repreſent your Inſtrument, AB being one Wing, AC the other Wing, and AD the moveable Thred. Upon

 the

the Wing A B is a Line of Sines, and upon the Wing A C is the Line of equal parts; upon which this proportion is to be wrought: Wherefore, the second term in the Proportion, being less than the first (according to the first general Rule) I take the second term (50) out of the Scale of equal Parts, and setting that distance in (80) the second term, I turn the other foot of the Compasses about, making a representative Arch, as E till I bring the Thred A D only to touch the moveable point of the Compasses, and there let the String rest (for it is fixed for this proportion.) Then setting one point of the Compasses in the third Term (48) I turn the other foot about, till



it

it only touch the Thred, making a repreſentative Arch, as at F. Laſtly, This diſtance of the Compaſſes meaſured upon the Line of equal parts, will reach from the beginning thereof, to 30; ſo that 30 is the fourth proportional term required; for,

As 80 is to 50 : : ſo is 48 : to 30.

Example 2.

But if the three proportional terms given, had been 50. 80. 30. then the Proportion muſt have been wrought according to the ſecond General Rule, by *Parallel Entrance*, as followeth.

Here, (becauſe the ſecond term is greater than the firſt, I take the firſt term (50) out of the Scale of equal parts, and ſetting one foot in the point of the ſecond term (80) I bring the Thred to the neareſt diſtance. Then out of the Scale, I take the third term (30) and with this diſtance of the Compaſſes, I move one foot thereof gently along the Scale of equal parts, till the other, being turned about, it may only touch the Thred, as by the Arch F in the Scheme is repreſented; and ſo you ſhall find the point of the Compaſſes to reſt in 48, which is the fourth proportional term required. For,

As 50 : is to 80 : : So is 30 : to 48.

This is very plain: And the like is to be done in all caſes, where the four terms be all of one kind, name or denomination. And if they be of different kinds, then the following Examples will make that plain alſo.

Wherefore let us take an Example in *Sines* and *equal Parts*, which are Terms of different denominations.

Example

Example 3.

Let the Terms of the Proportion be,
As Sine 60 d. to the numb. 35 :: So Sine 48 d. to what Number?

The first and second Terms are, Sine 60 d. and Number 35.

Now to know which of these two is the greatest; If you take 60 deg. out of the Line of Sines, you shall find it to be much longer than 35 of the equal parts; which shews that the proportion must be wrought upon the Scale of Sines.

And the second Term being less than the first, shews also, that it must be wrought by the first General Rule. Wherefore,

Take the second Term (35) out of the Scale of equal parts, and setting one foot of that extent in the second Term 60 deg. of the Signes, bring the Thred A G to the nearest distance (as at the Arch H,) and there let it rest: Then from the third Term (Sine 48 d.) take the nearest distance to the Thred (as at the Arch I) which distance being measured upon the Scale of equal parts, will reach from the beginning thereof to 30; so that the Number 30 is the fourth proportional Term: For,

As S. 60 d. is to N. 35 :: So is S. 48 d. to N. 30.

But to frame an Example that may fall under the second General Rule: Which, let be this.

Example 4.

Let the Terms of the Proportion be

As S. 60 d. to N. 90: So the S. of 48 d. to what Number?

Here by trial you ſhall find that the Number 90, (the ſecond Term) is greater than the Sine 60 d. (the firſt Term) and therefore the Proportion muſt be wrought upon the Line of equal parts; and the ſecond Term being greater than the firſt, it muſt be wrought by the ſecond General Rule. Wherefore, take 60 d. out of the Line of Sines, and ſetting one foot of that extent in 90, the ſecond Term, bring the Thred K to the neareſt diſtance, as at L, and there let it reſt; then from the Line of Sines, take the third Term (48 d.) and with this diſtance, move one foot of the Compaſſes along the Line of equal parts, till the other, being turned about, may only touch the Thred; and then will the Compaſs-point reſt upon the Line of equal parts, at $77\frac{1}{5}$, which is the fourth Proportional Number. For,

As S. 60 d. is to N. 90. So is S. 48 d. to N. $77\frac{1}{5}$.

Thus have you the ſeveral various wayes of working upon the Inſtrument; and theſe 4 Examples well underſtood, nothing that is to follow, will be difficult; for whatſoever before was done in equal parts alone, the like may be done, (and the ſame Rules are to be obſerved) in *Sines*, *Tangents*, *Squares*, *Cubes* alone alſo. And what is done in *Sines* and *equal parts*, the like may be done (with the ſame Cautions) in *Tangents* and *equal parts*.

Tangents

Tangents and *Sines*.
Sines and *Tangents*.
Equal Parts and *Squares*.
Squares and *Cubes*.
Cubes and *Equal Parts*, &c.

And having thus laid the Foundation, I ſhall now proceed to Examples of divers kinds, uſing all Brevity, and as much perſpicuity as may be.

SECT.

SECT. III.

Shewing some Uses of the Line of E-QUAL PARTS; singly in Arithmetick *and* Geometry.

I. *In* Arithmetick.

Prob. I.

To perform Multiplication *by the Line of Equal Parts.*

AS the *Multiplicand* is to the *Multiplier* (or the contrary) so is *One* (or *Unity*) to the *Product*.

The RULE.

Take the lesser of the two Numbers to be multiplied, out of the Line, and with that distance of the Compasses, set one foot in the Term of the greater Number; and bring the Thred to the nearest distance: Then from 10 *at the end of the line, take the nearest distance to the Thred; this distance shall reach from the beginning of the line to the Product of those two Numbers being multiplied together.*

The Uſes that I ſhall firſt inſiſt upon, ſhall be *ASTRONOMICAL*, and ſuch as concern the firſt Motions or Courſes of the *Sun* and *Stars*; which are the principal uſes to which the *Celeſtial Globe*, and other *Spherical Inſtruments*, as *Planiſpheres*, *Quadrants*, &c. are ſubſervient to.

Now becauſe it is neceſſary to the reſolution of ſuch *Aſtronomical Problemes*, to have the true *Place* and *Declination* of the Sun at any time given (which things the Inſtrument it ſelf will ſhew, the Day of the Moneth being only known; but not with ſuch exactneſs (in reſpect of the ſmalneſs thereof) as by ſome, at all times of the Year, it may be expected) I have therefore, in the Front of this Second Part, inſerted a Table, ſhewing the Place and Declination of the Sun for every Day in the Year: The uſe whereof, followeth after the Tables.

The

A Table of the Suns Place and Declination.

Days.	January. S. Place. d.	m.	S. Dec. d.	m.	Days.	February. S. Place. d.	m.	S. Dec. d.	m.	Days.	March. S. Place. d.	m.	S. Dec. d.	m.
01	21	♑ 45	21	46	01	23	♒ 15	13	49	01	21	♓ 21	03	27
02	22	46	21	36	02	24	16	13	29	02	22	20	03	03
03	23	47	21	26	03	25	17	13	09	03	23	20	02	40
04	24	48	21	15	04	26	17	12	48	04	24	19	02	16
05	25	50	21	04	05	27	18	12	27	05	25	19	01	52
06	26	51	20	52	06	28	18	12	06	06	26	18	01	29
07	27	52	20	40	07	29	19	11	45	07	27	18	01	05
08	28	53	20	27	08	00	♓ 19	11	24	08	28	18	00	41
09	29	54	20	14	09	01	19	11	02	09	29	17	00	18
10	00	♒ 55	20	01	10	02	20	10	41	10	00	♈ 16	00	06
11	01	57	19	48	11	03	20	10	19	11	01	16	00	30
12	02	58	19	34	12	04	20	09	57	12	02	15	00	54
13	03	59	19	19	13	05	21	09	35	13	03	14	01	18
14	05	00	19	05	14	06	21	09	13	14	04	14	01	41
15	06	01	18	50	15	07	21	08	51	15	05	13	02	25
16	07	02	18	35	16	08	21	08	28	16	06	12	02	59
17	08	03	18	19	17	09	21	08	06	17	07	11	03	02
18	09	04	18	03	18	10	22	07	43	18	08	10	03	16
19	10	05	17	47	19	11	22	07	20	19	09	09	03	39
20	11	06	17	30	20	12	22	06	57	20	10	08	04	02
21	12	07	17	14	21	13	22	06	34	21	11	07	04	25
22	13	08	16	56	22	14	22	06	11	22	12	06	04	48
23	14	09	16	39	23	15	22	05	48	23	13	05	05	11
24	15	09	16	21	24	16	22	05	24	24	14	04	05	34
25	16	10	16	03	25	17	21	05	01	25	15	03	05	57
26	17	11	15	44	26	18	21	04	38	26	16	02	06	19
27	18	12	15	26	27	19	21	04	14	27	17	01	06	42
28	19	13	15	07	28	20	21	03	51	28	18	00	07	05
29	20	13	14	48						29	18	58	07	27
30	21	14	14	28						30	19	57	07	49
31	22	15	14	00						31	20	55	08	11

January: South Declination.

February: South Declination.

March: South Declination. | North Declination.

A Table of the Suns Place and Declination.

Days.	April. S, Place. d.	m.	S. Decl. d.	m.	Days.	May. S. Place. d.	m.	S. Dec. d	m.	Days.	June. S. Place. d.	m.	S. Dec. d.	m.
1	21 ♈	54	8	34	01	20 ♉	58	18	04	01	20 ♊	37	23	12
2	22	53	8	56	02	21	56	18	19	02	21	34	23	16
3	23	51	9	17	03	22	53	18	34	03	22	32	23	19
4	24	50	9	39	04	23	51	18	49	04	23	29	23	22
5	25	48	10	1	05	24	48	19	03	05	24	26	23	25
6	26	47	10	22	06	25	46	19	17	06	25	23	23	27
7	27	45	10	43	07	26	44	19	30	07	26	20	23	29
8	28	43	11	4	08	27	41	19	43	08	27	17	23	30
9	29	42	11	25	09	28	39	19	56	09	28	15	23	31
10	0 ♉	40	11	45	10	29	36	20	09	10	29	12	23	32
11	1	38	12	5	11	00 ♊	34	20	21	11	00 ♋	09	23	32
12	2	37	12	26	12	01	31	20	33	12	01	06	23	32
13	3	35	12	46	13	02	29	20	44	13	02	03	23	31
14	4	33	13	5	14	03	26	20	56	14	03	00	23	30
15	5	31	13	25	15	04	24	21	07	15	03	57	23	28
16	6	29	13	44	16	05	21	21	17	16	04	54	23	27
17	7	27	14	3	17	06	18	21	27	17	05	51	23	25
18	8	25	14	22	18	07	16	21	37	18	06	48	23	22
19	9	23	14	41	19	08	13	21	46	19	07	46	23	18
20	10	21	14	59	20	09	10	21	55	20	08	43	23	15
21	11	19	15	17	21	10	08	22	03	21	09	40	23	11
22	12	17	15	35	22	11	05	22	11	22	10	37	23	06
23	13	15	15	53	23	12	02	22	19	23	11	34	23	01
24	14	13	16	10	24	13	00	22	27	24	12	31	22	56
25	15	11	16	27	25	13	57	22	34	25	13	28	22	50
26	16	9	16	44	26	14	54	22	40	26	14	25	22	44
27	17	7	17	1	27	15	51	22	46	27	15	22	22	38
28	18	5	17	17	28	16	49	22	52	28	16	20	22	31
29	19	2	17	33	29	17	46	22	58	29	17	17	22	24
30	20	0	17	49	30	18	43	23	03	30	18	14	22	17
					31	19	40	23	08					

North Declination.

North Declination.

North Declination.

A Table of the Suns Place and Declination.

Days.	July. S. Place. d.	m.	S. Dec. d.	m.	Days.	August. S. Place. d.	m.	S. Dec. d.	m.	Days.	September. S. Place. d.	m.	S. Dec. d.	m.
01	19 ♋	11	22	09	01	18 ♌	48	15	13	01	18 ♍	47	04	27
02	20	08	22	01	02	19	46	14	56	02	19	46	04	03
03	21	05	21	55	03	20	44	14	38	03	20	44	03	41
04	22	02	21	43	04	21	41	14	19	04	21	43	03	17
05	23	00	21	34	05	22	39	14	01	05	22	41	02	55
06	23	57	21	24	06	23	37	13	42	06	23	40	02	33
07	24	54	21	14	07	24	36	13	23	07	24	39	02	08
08	25	51	21	04	08	25	32	13	03	08	25	37	01	45
09	26	48	20	53	09	26	30	12	43	09	26	36	01	22
10	27	46	20	42	10	27	28	12	23	10	27	35	00	58
11	28	43	20	30	11	28	26	12	03	11	28	34	00	35
12	29	40	20	18	12	29	24	11	43	12	26	33	00	11
13	00 ♌	37	20	06	13	00 ♍	22	11	23	13	00 ♎	39	00	13
14	01	35	19	53	14	01	19	11	03	14	01	30	00	36
15	02	32	19	40	15	02	17	10	42	15	02	29	01	00
16	03	30	19	27	16	03	15	10	21	16	03	28	01	23
17	04	27	19	14	17	04	13	10	00	17	04	27	01	47
18	05	24	19	00	18	05	11	09	39	18	05	26	02	10
19	06	21	18	45	19	06	09	09	17	19	06	25	02	34
20	07	19	18	31	20	07	08	08	56	20	07	25	02	57
21	08	16	18	16	21	08	06	08	34	21	08	24	03	21
22	09	13	18	01	22	09	04	08	12	22	09	23	03	44
23	10	11	17	46	23	10	02	07	50	23	10	22	04	08
24	11	08	17	30	24	11	00	07	28	24	11	22	04	31
25	12	06	17	14	25	11	58	07	06	25	12	21	04	54
26	13	03	16	58	26	12	57	06	43	26	13	20	05	17
27	14	01	16	41	27	13	55	06	21	27	14	20	05	40
28	14	58	16	24	28	14	53	05	58	28	15	19	06	04
29	15	56	16	07	29	15	52	05	35	29	16	19	06	27
30	16	53	15	50	30	16	50	05	13	30	17	18	06	49
31	17	51	15	32	31	17	49	04	50					

North Declination. (July) — North Declination. (August) — North Declination. (September 1–12) — South Declination. (September 13–30)

A Table of the Suns Place and Declination.

Days.	October. S, Place. d.	m.	S. Decl. d.	m.	Days.	November. S. Place. d.	m.	S. Dec. d	m.	Days.	December. S. Place. d.	m.	S. Dec. d.	m.
1	18 ♎	18	7	11	01	19 ♏	21	17	38	01	19 ♐	49	23	08
2	19	17	7	34	02	20	21	17	54	02	20	51	23	13
3	20	17	7	57	03	21	22	18	10	03	21	52	23	17
4	21	16	8	19	04	22	23	18	26	04	22	53	23	20
5	22	16	8	43	05	23	23	18	42	05	23	54	23	23
6	23	16	9	05	06	24	24	18	57	06	24	56	23	26
7	24	15	9	26	07	25	25	19	11	07	25	57	23	28
8	25	15	9	48	08	26	26	19	25	08	26	58	23	30
9	26	15	10	10	09	27	26	19	39	09	28	00	23	31
10	27	15	10	33	10	28	27	19	53	10	29	01	23	32
11	28	15	10	53	11	29	28	20	07	11	00 ♑	02	23	32
12	29	15	11	15	12	00 ♐	29	20	20	12	01	03	23	32
13	0 ♏	15	11	36	13	01	30	20	32	13	02	05	23	31
14	1	15	11	57	14	02	31	20	44	14	03	06	23	30
15	2	15	12	18	15	03	32	20	56	15	04	07	23	29
16	3	15	12	39	16	04	33	20	08	16	05	09	23	27
17	4	15	12	59	17	05	34	21	19	17	06	10	23	24
18	5	15	13	19	18	06	35	21	30	18	07	11	23	20
19	6	15	13	39	19	07	36	21	40	19	08	13	23	16
20	7	16	13	59	20	08	37	21	50	20	09	14	23	12
21	8	16	14	19	21	09	38	21	59	21	10	15	23	08
22	9	16	14	38	22	10	39	22	08	22	11	17	23	03
23	10	16	14	58	23	11	40	22	16	23	12	18	22	57
24	11	17	15	17	24	12	41	22	24	24	13	19	22	51
25	12	17	15	35	25	13	42	22	32	25	14	21	22	45
26	13	18	15	54	26	14	43	22	39	26	15	22	22	38
27	14	18	16	12	27	15	45	22	46	27	16	23	22	31
28	15	19	16	29	28	16	46	22	54	28	17	25	22	24
29	16	19	16	46	29	17	47	22	58	29	18	26	22	15
30	17	19	17	4	30	18	48	23	03	30	19	27	22	07
31	18	20	17	21						31	20	28	21	58

South Declination.

South Declination.

The Use of the Foregoing TABLES *of the Suns* Place *and* Declination.

The Table consisteth of 12 *Parts*, representing the 12 Moneths of the Year, as appears by the *Titles* at the Head of each *Part*. Then on the left hand of each *Moneth* is set the number of Dayes therein contained; as *January* 31 days, *February* 28 days, *&c.* Again, in the other two Columns under each Moneth, the one contains the degrees and minutes of the Zodiack, in which the Sun is at noon, every day in the Year; and the other shews the *Suns Declination* from the *Equinoctial* either *Northward* or *Southward* every day at Noon.

Example. I desire to know the *Suns Place*, and consequently, his *Declination* upon the first day of *January*, Look in the Table for *January*, and against the first day thereof you shall find 21 *Capricorn* 45, in the Column under the *Suns* place, which shews, that the Sun, that day at Noon, is in 21 d. and 45 m. of *Capricorn*; and in the next Column under [*S. Decl.*] you shall find 21 46, that shews that that day, at Noon, the Sun is declined from the *Equinoct. Southw.* 21 d. and 46 m. And thus you may find the Suns Place and Declination for any day in the Year; as,

		d.		m.		d.	m.	
Mar. 16	The Sun will be in	6	*Aries*	12	And his Dec. will be	2	59	N.
May 11		0	*Gem.*	34		20	21	N.
Aug. 27		13	*Virg.*	55		6	21	N.
Oct. 18		5	*Scor.*	15		13	19	S.
Nov. 26		14	*Sag.*	43		22	39	S.

And

113 And here note, that the Sun never declineth from the *Equinoctial*, Northward or Southward, more than 23 d. 32 m. which is his greatest Declination; and such Declination he hath, when he enters into *Cancer* or *Capricorn*, which is about the 11 of *June*, and the 11 of *December*, making the longest and shortest days; and when the Sun is in the *Equinoctial*, he hath then no *Declination* at all, and then the Days and the Nights are of equal length throughout the World; and that is about the 10*th.* of *March*, and the 12*th.* or 13*th.* of *September*.

And note further, that from the 10*th.* of *March*, to the 12*th.* or 13*th.* of *September*, the Sun hath *North Declination*, and he is in *Northern Signes*, viz. *Aries*, *Taurus*. *Gemini*, *Cancer*, *Leo* or *Virgo*. And from the 12*th.* or 13*th.* of *September*, to the 20*th.* of *March*, he hath *South Declination*, and he is in some of the *Southern Signs*, as in *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius* or *Pisces*. All which is visible in the *Table*, according to the respective *Titles*; and therefore no more need be said concerning it in this place.

X

Problemes

Problemes Astronomical:

PERFORMED

By the SCALES upon the Quadrantal part of the *INSTRUMENT*.

SECT. I.

I. *Of the two Curved Scales of Moneths.*

Prob. 1.

Any Day of the Year being given, to find what other Day of the Year is of the same length therewith.

LET it be required to find what day of the Year is of equal length with the 18*th* of *October*. Lay the thred to the 18*th.* day of *October* in the lower Curve, then will the thred cut the uppermost Curve on the third day of *February*, which day is nearest of the same length with the 18*th*, of *October*; So shall you find the

1 of *March* 12 of *August* 1 of *May*	to be near of e- qual length with the	21 of *September*. 10 of *April*. 22 of *July*.

And so of any other day of the Year.

II. *Of the* Zodiack.

Prob. 2.

The Day of the Moneth being given, to find the Suns place in the Zodiack.

LAy the thred to the day of the Moneth, and it will shew you in the Ecliptick the place of the Sun.

Let the day given be the 16*th*. of *April*, the thred laid to the 16*th*. of *April* will cut the *Zodiack* in 6. deg. 29 min. of ♉ *Taurus*, in which Sign and Degree the Sun is upon the 16*th*. of *April*.

Note, That if you find the day of the Moneth in the upper Curve of Moneths, the Sun is in those Signes that are Charactered upon the upper part of the *Zodiack*. But if you find the day of the Moneth in the lower Curve, then the Sun is in those Signs that are Charactered under the *Zodiack*.

So shall you find that on

the 12 of *January* the 26 of *April* the 1 of *September* the 18 of *October*	the Sun will be in	2 deg. 58 m. of ♒. 16 deg. 9 m. of ♉. 18 d. 47 m. of ♍. 5 d. 15 m. of ♏.

Prob.

Prob. 3.

The Place of the Sun being given, to find the day of the Moneth.

LAy the Thred to the Suns place in the *Zodiack*, and it will cut the day of the Moneth either in the upper or under Curve.

So the Sun being in 18 deg. of ♎, the Thred laid thereto, will cut the 1 of *October* in the under Curve, which is the day of the Moneth. Alſo the Sun being in 13 d. 15 m. of ♉, it will cut the uppermoſt Curve in the 23 of *April*, which is the day of the Moneth.

For, If the Character of the Suns place be found under the *Zodiack*-Line, the day of the Moneth is in the undermoſt Circle; but if the Character of the Sign be above the Line, then the day of the Moneth is in the uppermoſt Circle of Moneths.

III. *Of the Arch of Declination.*

Prob. 4.

The day of the Moneth being given, to find the Suns Declination.

LAy the Thred to the day of the Moneth, and it will cut the Line of Declination (or the degrees of the

 equal

equal Limb counted from either ſide of 60 d.) in the Declination required.

So the day of the Moneth being the *6th.* of *May*, the Thred laid thereto, will cut the Line of Declination, (or the Limb from 60) in 19 d. 20 m. which is the Declination of the Sun Northward upon the *6th.* of *May*.

Prob. 5.

The Suns Declination being given, to find the day of the Moneth.

LAy the Thred to the Suns Declination in the Line of Declination, and it will cut the day of the Moneth both in the upper and lower Curve.

So the Suns Declination being 8 deg. South, the thred laid thereto, will cut the *16th.* day of *February*, in the uppermoſt Curve, and the *3d.* of *October* in the lower Curve, on either of which dayes the Sun hath about 3 deg. of South Declination.

And here note alſo, that if the Thred being laid to the day of the Moneth, do fall on the right hand of 60 deg. the Sun hath North Declination; but if it fall on the left hand of 60, the Sun hath South Declination.

Prob. 6.

The Suns place in the Ecliptick *being given, to find his Declination.*

LAy the Thred to the Suns place in the *Zodiack*, and it will cut the Line of Declination in the point required.

So the Sun being in 1 deg. of ♉, the Thred laid thereto, will cut the Line of Declination in 11 deg. 52 m. of North Declination, and ſuch Declination hath the Sun when he is in the firſt deg. of *Taurus*.

IV. *Of the Limb of the Quadrant.*

Prob. 7.

How to take the Suns Altitude by the Quadrant, *as alſo the Altitude of the Moon or Stars.*

BEcauſe moſt of the Propoſitions following require the Suns Altit. to be given, it will be neceſſary here to ſhew the manner how to take it at any time by the *Quadrant*, the Sun ſhining.

Upon the edge of your *Quadrant* are two Sights for this purpoſe. Take the *Quadrant* in both your hands, laying your right hand ſomewhat near that ſide that hath the Sights, and your left hand towards the other ſide, by which means you may let it ſlip lower, or raiſe it higher, as occaſion requires; then turning the left

left side of your Body to the Sun, hold the *Quadrant* in both your hands, as is before directed, and move it up and down in your hand till the Sun shining through that Sight which is next the Center of the *Quadrant*, do cast his Ray or Beam of Light upon the Hole of the other Sight, at which instant look in the Limb of the *Quadrant*, what degree and parts of a degree the Thred resteth upon; for those degrees are the degrees of the Suns Altitude. Thus for taking the Suns Altitude; but for the Moon or Stars you must hold the *Quadrant* in both your hands, as before, and look through both the Sights, till you espie the Moon or Star, whose Altitude you require, which when you have found, looke what degrees the thred cuts in the Limb of the *Quadrant*; for those degrees are the Altitude of the Moon or Star you look at.

Likewise in the taking of Altitudes of Buildings, *&c.* you must look through the Sights till you see (through them) the top of the Object whose height you would know.

V. *Of the Houre or* Azimuth *Scales.*

Prob. 8.

TO find the Hour and Minute of the Suns Rising and Setting, with the length of the Day and Night.

LAy the Thred to the day of the Moneth, either in the upper or under Curve, so shall it cut the Scale of Hours in your respective Latitude, upon the just Hour and minute of the Suns Rising and Setting. So

So the day of the Moneth given, being the 10*th* of *April*, the Thred laid thereto, will cut the Line of Hours exactly in the point marked with 7, V, ſhewing that the Sun riſeth juſt at five a Clock in the Morning, as appears by V, and ſets at ſeven a Clock at night, as the Figure 7 repreſenteth.

Likewiſe, the Thred laid to the 8*th.* day of *November*, the Thred will cut the Hour-Scale at 45 min. paſt ſeven a Clock for the Sun-riſing, and at 4 a Clock and 15 min. for the Sun-ſetting.

If you double the Hours and Minutes of the Suns riſing, you have the length of the Night; and the Hours and Minutes of the Suns Setting doubled, give the length of the Day.

So on the former 8*th.* of *November*, the Sun riſeth at 7 hours 45 min. which doubled, makes 15 hours, 30 min. for the length of the night. And the Sun ſets at 4 hours 15 min. which being doubled, makes 8 ho. 30 min. for the length of the Day.

Prob. 9.

The Suns place in the Zodiack *being given, to find the Amplitude of the Suns Riſing or Setting.*

THe Amplitude of the Suns Riſing or Setting is the diſtance that the Sun riſeth or ſetteth from the true Eaſt or Weſt Points of the Horizon towards either North or South. To find this Amplitude,

Set one foot of your Compaſſes in the Point of the Zodi-

Zodiack marked with ♈ and ♎, extend the other to the Suns place in the ſame *Zodiack*, apply this diſtance of the Compaſſes to the *Azimuth*-Scale, appropriate to the Latitude in which you are, by ſetting one Foot in 90 deg. and turning the other towards the right hand in Summer, and towards the left in Winter, ſo ſhall the other Foot of the Compaſſes reſt upon the degrees of Amplitude from the Eaſt or Weſt, if you reckon the degrees included between 90 and the other foot of the Compaſſes; or elſe it gives you the Amplitude from the South if you reckon the degrees as they are numbred from the beginning of the Line.

So the Sun being in the 1 deg. of ♒; take with your Compaſſes the diſtance from ♈ or ♎ to one degree of ♒ out of the *Zodiack*; one foot of this diſtance being ſet from 90 in the *Azimuth*-Scale, the other being turned towards the left hand (becauſe it is in Winter) will reſt upon 33 d. 44 m. counted from 90, which is his Amplitude from the Eaſt or Weſt, or upon 56 deg. 16 min. counted from the beginning of the Scale, which is the Amplitude from the South, becauſe the Sun is in a Southern Sign.

In like manner, if the Sun had been in 4 deg. of ♊, the Amplitude would have been found to be 35 deg. 36 min. from the Eaſt or Weſt; or, 35 deg. 36 min. from the South, which is 54 deg. 24 min. from the North, becauſe it is Summer, and the Sun is in a Northern Sign.

Prob.

Prob. 10.

THE Suns place in the Zodiack *being given, to find the Declination another way, differing from that in the* 4th, Probl.

TAke with your Compaſſes the diſtance from ♈ or ♎ to the Suns place in the *Zodiack*, apply that diſtance to the Scale of the Suns Altitude, or Line of Sines, from the beginning thereof, ſo ſhall the other foot ſhew the declination required.

So the Sun being in 29 deg. of ♉, this diſtance being taken from ♈ or ♎ out of the *Zodiack*, will reach from the beginning of the Line of the Suns Altitude, or Line of Sines, to 20 deg. and ſuch is the Suns declination Northward, becauſe the Sun is in a Northern Sign.

Prob. 11.

The Day of the Moneth (or place of the Sun in the Zodiack*, or his Declination) being given, to find the Suns Altitude at all hours.*

THis Propoſition is of ſingular uſe in the making of Inſtrumental Dials, as Equinoctial Rings, and Cylinder-Dials, as alſo in the making Quadrants and other Inſtruments that give the hour of the Day, by

the Altitude of the Sun. It is also of special use in putting into all sorts of reflex Dials and others, the Signes of the Zodiack, the Parallels of the length of the Day, and other kind of Furniture for the adorning and beautifying of large Plains, of which, I shall have occasion to discourse more at large in another place. The Proposition is thus to be performed:

Lay the Thred to the Day of the Moneth upon which you desire to the know Altitude of the Sun at all hours; the thred there resting, take with your Compasses the least distance from each hour-point in the Scale of hours (answerable to the Latitude desired) and measure those distances upon the Line of the Suns Altitude, or Line of Sines, the number of degrees and minutes which the point of the Compasses rest upon, shall be the degrees and minutes of the Suns Altitude at that hour.

So in our Latitude of 51 d. 30 m. If we were required to find what Altitude the Sun shall have at all hours upon the 12 of *August*, at which time the Sun is in the beginning of *Virgo*: Lay the Thred to the 12 of *Aug.* or beginning of *Virgo*, and keep it there; then,

First, Take with your Compasses the distance from XII in the Hour-Scale to the Thred, and apply this distance to the Scale of the Suns Altitude, or Line of Sines, it will reach from the beginning thereof to 50 d. and such is the Altitude of the Sun at 12 of the Clock upon the 12 of *August*.

Secondly, Take the least distance from XI and 1 a Clock in the Hour-Scale to the Thred, this distance applied to the Line of Sines, or Scale of the Suns Altitude, gives 48 d. 12 m. for the Suns Altitude at Eleven or One of the Clock on the said 12 of *August*, &c.

Do

Do the like for all the other hours of that day, and you shall find

			deg.	min.
the Suns Alt. at	X or 2	to be	43	12
	IX or 3		36	0
	VIII or 4		27	31
	VII or 5		18	18
	VI or 6		9	0

By this Rule you may make Tables for the Suns Altitude at all hours of the day, for any day of the year, or for any degree of the Sun in the *Zodiack*, or for any degree of the Suns Declination; of one of which, I have here given you an Example, which is

A Table shewing what Altitude the Sun shall have at every hour of the day, the Sun being in the beginning of each Sign, in Latitude 51 *d.* 30 *min.*

Morn. hour / Aftern. hou	XII		XI 1		X 2		IX 3		VIII 4		VII 5		VI 6		V 7		IV 8	
♋	62	0	59	43	53	45	45	42	36	41	27	17	18	11	9	32	1	32
♊ ♌	58	42	56	34	50	55	43	6	34	13	24	56	15	40	6	50		
♉ ♍	50	0	48	12	43	12	36	0	27	31	18	18	9	0				
♈ ♎	38	30	36	58	32	37	26	7	18	8	9	17						
♓ ♏	27	1	25	40	21	51	15	58	8	33	0	6						
♒ ♐	18	18	17	6	13	38	8	12	1	15								
♑	15	0	13	52	10	30	5	26										

This Table is of good uſe for the making of ſuch Inſtrumental Dials as I mentioned in the beginning of this Prop.

When the Sun is in the Equinoctial, there is no need of the Thred; for then you need only take the diſtance from VI to every other hour, and apply thoſe diſtances to the Scale of right Sines, and thoſe Extents there meaſured, ſhall be the Suns Altitude at thoſe reſpective hours.

Note, That whatſoever is in this *Prop.* ſaid concerning whole hours, the like is to be underſtood of parts of hours, as halves and quarters, *&c.*

Prob. 12.

The Suns place or declination being given, to find what Altitude he ſhall have when he cometh to be due Eaſt or Weſt.

TAke with your Compaſſes the diſtance from *Aries* to the Suns place in the *Zodiack*, with this diſtance of the Compaſſes ſet one foot in 90 in the *Azimuth*-Scale proper for your Latitude, then turning the other about, bring the Thred till it only touch the moveable point of the Compaſſes, then count how many degrees of the Quadrants Limb are contained between the Thred and 60 deg. for ſo many degrees high ſhall the Sun be when he is juſt upon the Eaſt or Weſt points.

So

So the Sun having 20 deg. of Declination, his place then being in 29 deg. of *Taurus*, if you take with your Compasses the distance between *Aries* and 29 deg. of *Taurus* out of the *Zodiack*, and set one foot of that extent in 90 on the *Azimuth*-Scale; if you turn the other foot about, and bring the Thred to touch the moveable point, the Thred will then cut the Limb in 25 deg. 55 min. counted in the Limb of the Quadrant from 60 towards the left hand, and such altitude shall the Sun have when he cometh to be due East or West.

Prob. 13.

The place of the Sun being given, to find what Altitude he shall have upon any Azimuth.

THis Proposition is of good use for the framing of Tables for the ready making of Instruments that shew the *Azimuth* of the Sun by the Altitude given, the working whereof differeth little from the former Prop.

For, if you take with your Compasses the distance from *Aries* to the Suns place out of the *Zodiack*, and set one foot of that distance upon the *Azimuth-Scale*, proper for your Latitude (upon that *Azimuth* on which you require the Suns Altitude) and turn the other about till the Thred only touch the moveable point, the Thred will cut in the Limb the degrees of the Suns Altitude upon the given *Azimuth*, if you count the Degrees from 60 towards the left hand.

So

So if the Sun were in the beginning of *Sagitarius*, and it were required, to find what Altitude he should have when he shall be upon the 40 *Azimuth* from the Meridian; if you take with your Compasses the distance from *Aries* to *Sagitarius*, and set one foot thereof upon 40 degrees in the *Azimuth*-Scale, and bring the Thred till it only touch the moveable point of the Compasses, you shall find the Thred to rest at 9 deg. 14 min. of the Quadrants Limb counted from 60, and such is the Altitude of the Sun upon the 40*th*. *Azimuth* from the Meridian, when he is in the beginning of *Sagitarius*; and the like for any other *Azimuth*, or any other place of the Sun in the *Zodiack*. According to this Proposition, it being of such singular use, I have framed

A Table shewing what Altitude the Sun shall have upon every 10th. Azimuth *in the beginning of each Sign in Latitude* 51 d. 30 m.

Azimuths	♋ d.	♋ m.	♊ ♌ d.	♊ ♌ m.	♉ ♍ d.	♉ ♍ m.	♈ ♎ d.	♈ ♎ m.	♓ ♏ d.	♓ ♏ m.	♒ ♐ d.	♒ ♐ m.	♑ d.	♑ m.
0	62	0	58	42	50	0	38	30	27	0	18	18	15	0
10	61	43	58	24	49	38	38	4	26	30	17	45	14	25
20	60	51	57	28	48	33	36	46	25	10	16	5	12	41
30	59	52	55	52	46	40	34	34	22	27	13	15	9	45
40	57	20	53	29	43	55	31	21	18	48	9	14	5	34
50	54	03	50	12	40	11	27	5	13	58	3	57	0	6
60	49	56	45	53	35	23	21	41	8	0				
70	44	40	40	25	29	27	15	13	1	0				
80	28	11	33	46	21	29	7	52						
90	30	38	26	10	14	25								
100	22	27	18	2	6	45								
110	14	14	9	58										
120	6	34	2	30										

In working of this *Prop.* by the Quadrant, when the Sun is in the Equinoctial, there will be no need of the use of the Compasses; for if you lay the Thred upon any number of the degrees of the *Azimuth* in the *Azimuth*-Scale, the Thred will cut the Limb of the Quadrant in the degrees of Altitude that the Sun shall have upon that *Azimuth* upon which the Thred lies, if you count the degrees of the Quadrants Limb from 60 towards the left hand.

Note, In the working of this *Proposition*, that if the Sun be in a Northern Sign, and have North declination, the moveable point of the Compasses, and the Thred [illegible] wards the left hand edge of the Quadrant, but when the Sun is in South Signes, towards the right hand or right edge of the Quadrant.

Prob. 14.

The Suns Altitude, and his place in the Zodiack *being given, to find his* Azimuth *from the South.*

TAke with your Compasses the distance from *Aries* to the Suns place in the *Zodiack*, and lay the Thred to the Suns Altitude, counted from 60 in the Limb of the Quadrant towards the left hand; then, setting one foot of your Compasses upon the *Azimuth*-Scales proper for your Latitude, move it gently along the same, till the other foot being turned about, may only touch the Thred; so shall the Compasse-point rest

rest just upon the *Azimuth* from the South.

So the Sun being in the third degree of *Virgo*, and his Altitude being 35 deg. If you take the distance between *Aries* and *Virgo*, out of the *Zodiack*, and lay the Thred to 35 deg. the Suns Altitude (counted in the Quadrants Limb from 60 towards the left hand) and set one foot of the Compasses upon the *Azimuth*-Scale, and there move it along (either backward or forward) till the other foot being turned about, do only touch the Thred; so shall you find the foot of the Compasses to rest upon the *Azimuth*-Scale at 60 deg. 42 min. and that is the Suns *Azimuth*, from the South, when he is in the beginning of *Virgo*, and grees from 90 to the place where the Compasses do rest, you shall find them to be 29 deg. 18 min. which is the Suns *Azimuth* from either East or West, according to the time of the day in which you observed the Altitude.

Prob. 15.

The Suns place together with its Altitude, being given, to find the hour of the Day.

LAy the thred to the day of the Moneth, (or to his place in the *Zodiack*) and take the Altitude out of the Scale of the Suns Altitude, or Line of Sines, with this distance; set one foot of the Compasses upon the Hour-Scale proper to your Latitude, moving the same, till the other foot being turned about, may only

only touch the Thred, ſo ſhall the Compaſs-point reſt upon the true hour from Noon.

So the Sun being (as before) in the beginning of *Virgo*, and his altitude 35 deg. if you lay the Thred thereto, and take 35 deg. (the Suns altitude) out of the Scale of right Sines, and apply one Foot of this diſtance to the Hour-Scale, moving it along till the other Foot being turned about, do only touch the Thred, you ſhall find the Foot to reſt at 3 hours, and about 7 min. from the Meridian, which ſhews that it is 7 min. paſt 3, if it be in the Afternoon; or wants 7 min. of IX, if it be in the Forenoon.

Note, That every hour (except thoſe near 12) is divided into 15 parts or degrees, each part or degree repreſenting four minutes of time.

Prob. 16.

To find the moment of time when the Crepuſculum *or Twilight begins or ends, the Sun being in any degree of North or South Declination.*

LAy the Thred to the contrary Declination to what the Sun is in, that is to ſay, if the Sun have 20 deg. of North declination, then take (alwaies) 18 d. out of the Line of the Suns Altitude, or Line of Sines; and ſetting one Foot of that extent upon the hour-Scale, moving it along till the other only touch the Thred, the point of the Compaſſes will reſt upon the time of the beginning or ending of the Twilight, counted from Midnight.

Thus the Sun having 11 deg. 31 min. of North declination, if you lay the Thred to 11 deg. 31 min. of South declination, and take 18 deg. out of the Scale of the Suns Altitude, moving one Foot of that extent upon the Hour-Scale, till the other touch the Thred, you shall find the Compass-point to rest upon something more than 41 min. past 2 in the morning, and the evening-Twilight will end at about 18 min. past 9 at night.

Note here, That in Summer it may so fall out, that the extent of 18 deg. of the Sines will not come to touch the Thred, and rest upon the Hour-Scale; all which time you must know, that there is no dark night at all; but the Twilight lasteth all night long; which here in this our Latitude of *London*, is from about the 12 of *May* to the 13 of *July*; in all which time the Sun doth not descend 18 deg. below our Horizon.

The End of the ASTRONOMICAL PROBLEMES.

Problemes in Dialling:

Both *UNIVERSAL* and *PARTICULAR.*

PERFORMED

By the Lines inſcribed on the Quadrantal part of the *INSTRUMENT.*

SECT. II.

A Declaration and Deſcription of the ſeveral Plains upon which Dials are to be made.

THE Lines upon the foreſide of the Inſtrument are of ſingular uſe in the uſe of *Dialling*; for by them may be made with great eaſe and exactneſs, all the moſt uſual ſorts of *Sun-Dials* in any Latitude that is deſcribed upon the Inſtrument; as all *Horizontal*, and *erect*, *direct* North, South, Eaſt or Weſt Dials; alſo all direct Eaſt, Weſt, North or South *Reclining* or *Inclining* Dials; and all *upright* Dials whatſoever, whether *direct* or *declining*: And of theſe in order.

But before I come to ſhew you how to make the Dials, it will be neceſſary to diſcover unto you what Plains are ſo, and ſo denominated: And therefore,

1. *An* Horizontal *Plain*,

Is ſuch a Plain as lieth exactly parallel to the Horizon, and ſuch are thoſe Dials as are uſually made and ſold to ſet upon the top of a Poſt in a Garden, or elſewhere; the top of the Poſt or other thing, upon which the Dial is fixed, lying level or parallel to the Horizon of the place.

2. *An* Erect *Plain*

Is ſuch a Plain as is perpendicular to the Horizon; as are the ſides of Walls of any upright Building whatſoever; whether Tower, Steeple, Houſe, or the like. And of theſe Erect Plains there are two ſorts.

1. Erect direct. And,
2. Erect declining.

So,

3. *An* Erect direct *Plain*,

Is ſuch a Plain, as being erect, or perpendicular to the Horizon as before, doth alſo behold, or look directly towards, either the true Eaſt, Weſt, North or South-points of the Heavens; and all Plains that are erect or upright, and thus ſituate, are called *Erect direct* Plains.

4. An

4. *An* Erect declining *Plain*.

Is ſuch a Plain, which though it be erect or upright, doth not directly behold the true East, Weſt, North or South-points of the Heavens, but looketh obliquely, or declineth from either of thoſe points, and ſo is termed an *Erect*, but *Declining* Plain. And the Declination of ſuch Plains, is alwaies accounted from the North or South points of the Heavens, towards the East or Weſt. For, if a Wall or Plain lying open towards the South, but doth not directly behold the South, it is ſaid to decline; and if this Declination be (when you look upon the Plain) towards the right hand, the Plain is ſaid to be an *Erect Plain*, declining from the South *Eaſtward*. But if this Declination of the South be towards the left hand, the plain is ſaid to be an *Erect Plain* declining from the South *Weſtward*. And what is here ſaid of *South declining Plains*, the ſame is to be underſtood of *North-decliners* alſo; for of theſe Plains, there is only four varieties; and thoſe are,

South-declining	East	which beholdeth both the	South and the East.
	Weſt		South and the Weſt.
North-declining	East		North and the East.
	Weſt		North and the Weſt.

5. *A* Reclining *Plain*.

Is ſuch a Plain as is ſituate neither parallel or level with the Horizon, as the Horizontal Plain is; nor yet erect

erect or perpendicular thereunto, as the Plains laſt deſcribed; but reclineth or bendeth from the *Zenith* of the place towards the Horizon, making an Angle therewith: And ſuch Plains as theſe, I cannot better define unto you, than by comparing them to the Roof or Covering of a Houſe, the outſide of the Tiling whereof is a *Reclining* Plain.

6. *An* Inclining *Plain.*

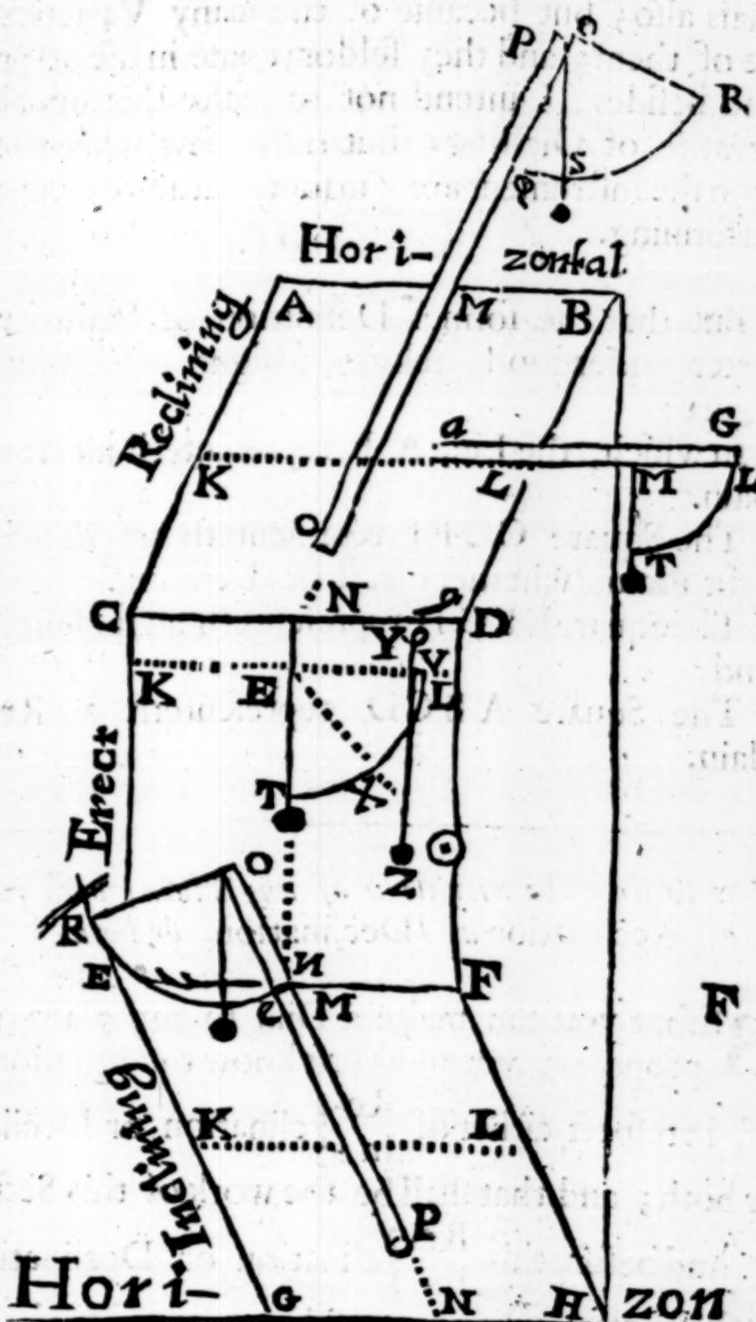
As the Reclining Plain was compared to the outſide of the Tileing or Covering of a Houſe, ſo may the Inclining Plain be alſo compared to the Inſide, or under part of the Covering of a Houſe.

Now of *Reclining* and *Inclining* Plains, there are the ſame Varieties as of *Erect Plains*; for if they do directly behold either the East, Weſt, North or South-Points of the Heavens, they are termed *Direct Recliners* or *Incliners*: But if they do not directly behold any of thoſe Points, they then decline, and are termed

South or North } Reclining } Declining Plains.
South or North } Inclining }

But of this laſt ſort of Reclining and Inclining Plains Declining, I ſhall ſay nothing in this place; not but that the Lines upon the Inſtrument will make thoſe

Dials


P
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Dials alſo; but becauſe of the many Varieties there are of them; and they ſeldom come in uſe or practiſe: And beſides, I intend not to make this an abſolute Treatiſe of Dialling; but only ſhew what the Lines upon the Inſtrument are (in ſome meaſure) capable of performing.

But that the former Definition of Plains may be better underſtood, take the ſight of the foregoing Figure:

In which, the Line A B repreſenteth an Horizontal Plain.

The Square CDEF repreſenteth an Erect or Upright Plain, whether direct or declining.

The Square E F G H repreſenteth an Inclining Plain. And,

The Square A B C D repreſenteth a Reclining Plain.

How to find the Situation of any Plain, both in reſpect of Reclination *and* Declination, *or both.*

BEfore you can make a Dial to any place or Plain propoſed, you muſt firſt know the ſituation thereof, in reſpect either of Re-/In- clination or Declination, or both; and that ſhall be the work of this Section.

And before this Re-/In- clination or Declination can well be attained, you muſt know

How

How to draw an Horizontal Line upon any Plain.

1. Upon ſuch a Plain as we call Horizontal (or Level) infinite Horizontal Lines may be drawn; for the Plain it ſelf being an Horizon, every Line drawn thereon is an Horizontal Line. But,

2. Upon an *Erect Plain*, ſuch as is C D E F, one Horizontal Line drawn thereon is ſufficient; and ſuch an Horizontal Line is the Line K M L, which is to be drawn in this manner.---Your Inſtrument or Quadrant, having a Thred in the Centre, with a Plummet at the end of it, apply the back-ſide of your Inſtrument flat-wiſe to the Wall or Plain, moving it up or down, till ſuch time as the Thred and Plummet hang directly upon the Line M T (as is repreſented in the Figure upon the Plain C D E F,) and then by the edge of the Quadrant M L, draw the right Line K M L, which ſhall be the Horizontal Line of the Erect Plain C D E F.

3. To draw this Horizontal Line upon a Reclining Plain, lay a Ruler, as *a b*, thereunto, and to the under-edge of the Ruler, apply the ſide of your Inſtrument M L, moving the Ruler and Quadrant both together, upwards or downwards, till the Thred and Plummet fall juſt upon the Line M T of the Inſtrument; then draw a Line by the ſide of the Ruler, and that ſhall be the Horizontal Line of the Plain, and is repreſented in the Scheme before-going in the Reclining Plain A B C D, by the Line K L.

4. To draw this Horizontal Line upon any inclining Plain, it is to be effected in the ſame manner as in the reclining Plain, and this Horizontal Line is repreſented by the Line K L in the inclining Plain E F G H.